

# **ML361 Virtex-II Pro DDR400/PC3200 Memory Board User Guide**

UG060 (v1.2) November 8, 2007





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## ML361 Virtex-II Pro DDR400/PC3200 Memory Board User Guide UG060 (v1.2) November 8, 2007

The following table shows the revision history for this document.

	Version	Revision
01/23/04	1.0	Initial Xilinx release.
03/26/04	1.1	Revised <a href="#">Figure 4-6</a> , <a href="#">Figure 4-7</a> , <a href="#">Figure 4-8</a> , <a href="#">Figure 4-9</a> , <a href="#">Figure 4-26</a> , and <a href="#">Figure 4-27</a> .
11/08/07	1.2	<ul style="list-style-type: none"><li>• <a href="#">Table 5-1</a>: Typographical corrections.</li><li>• <a href="#">Table B-1</a>: Deleted <b>Slice Coordinates</b> column from table.</li><li>• Updated copyright notice and legal disclaimer.</li></ul>

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## About This Guide

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This document describes the design of the ML361 Virtex-II Pro™ DDR400/PC3200 Memory Board, which connects a Virtex-II Pro FPGA to DDR memories.

### Guide Contents

This manual contains the following chapters:

- [Chapter 1, "Introduction,"](#) describes the purpose of the ML361 board and provides its key features.
- [Chapter 2, "Architecture,"](#) provides a block diagram of the memory board and describes the key components.
- [Chapter 3, "Electrical Requirements,"](#) lists the electrical specifications for the memory board.
- [Chapter 4, "Signal Integrity Recommendations and Simulations,"](#) provides information on termination, transmission lines, and duty cycles. It also gives the results of several IBIS simulations.
- [Chapter 5, "Board Layout Guidelines,"](#) provides information on decoupling capacitors, ground signals, and PCB layout.
- [Appendix A, "Related Documentation,"](#) lists data sheet and external website references specific to the ML361 components.
- [Appendix B, "FPGA Pinout,"](#) provides the pinout of the Virtex-II Pro FPGA.

### Additional Resources

For additional information, go to <http://support.xilinx.com>. The following table lists some of the resources you can access from this website. You can also directly access these resources using the provided URLs.

Resource	Description/URL
Tutorials	Tutorials covering Xilinx design flows, from design entry to verification and debugging <a href="http://support.xilinx.com/support/techsup/tutorials/index.htm">http://support.xilinx.com/support/techsup/tutorials/index.htm</a>
Answer Browser	Database of Xilinx solution records <a href="http://support.xilinx.com/xlnx/xil_ans_browser.jsp">http://support.xilinx.com/xlnx/xil_ans_browser.jsp</a>
Application Notes	Descriptions of device-specific design techniques and approaches <a href="http://support.xilinx.com/apps/appsweb.htm">http://support.xilinx.com/apps/appsweb.htm</a>

Resource	Description/URL
Data Sheets	Device-specific information on Xilinx device characteristics, including readback, boundary scan, configuration, length count, and debugging <a href="http://support.xilinx.com/xlnx/xweb/xil_publications_index.jsp">http://support.xilinx.com/xlnx/xweb/xil_publications_index.jsp</a>
Problem Solvers	Interactive tools that allow you to troubleshoot your design issues <a href="http://support.xilinx.com/support/troubleshoot/psolvers.htm">http://support.xilinx.com/support/troubleshoot/psolvers.htm</a>
Tech Tips	Latest news, design tips, and patch information for the Xilinx design environment <a href="http://www.support.xilinx.com/xlnx/xil_tt_home.jsp">http://www.support.xilinx.com/xlnx/xil_tt_home.jsp</a>

## Conventions

This document uses the following conventions. An example illustrates each convention.

### Typographical

The following typographical conventions are used in this document:

Convention	Meaning or Use	Example
<i>Italic font</i>	References to other manuals	See the <i>Development System Reference Guide</i> for more information.
	Emphasis in text	If a wire is drawn so that it overlaps the pin of a symbol, the two nets are <i>not</i> connected.

### Online Document

The following conventions are used in this document:

Convention	Meaning or Use	Example
<a href="#">Blue text</a>	Cross-reference link to a location in the current document	See the section " <a href="#">Additional Resources</a> " for details. Refer to " <a href="#">Title Formats</a> " in <a href="#">Chapter 1</a> for details.
<a href="http://www.xilinx.com">Blue, underlined text</a>	Hyperlink to a website (URL)	Go to <a href="http://www.xilinx.com">http://www.xilinx.com</a> for the latest speed files.

## Introduction

### Overview

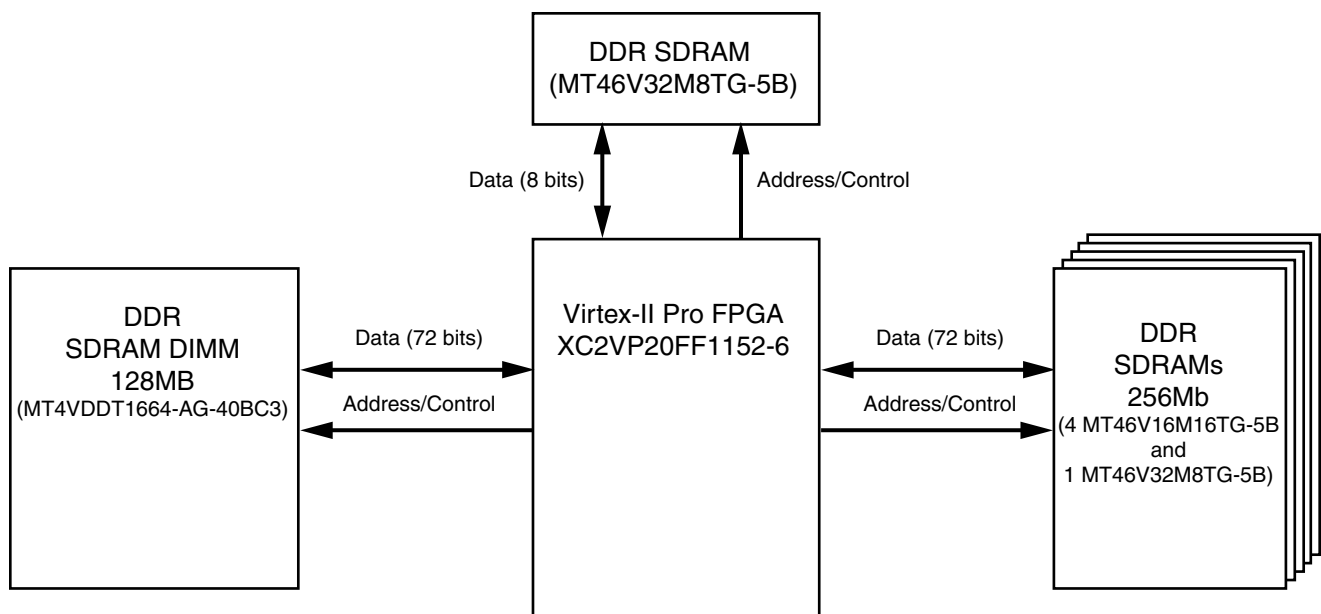
The ML361 Virtex-II Pro DDR400/PC3200 Memory Board provides a communications platform between a Virtex-II Pro FPGA and high-speed double-data-rate (DDR) memories with operating speeds up to 200 MHz. The ML361 has three major functions:

- Tests and verifies the interoperability of Virtex-II Pro devices with high-speed DDR memories
- Serves as a development platform for Xilinx and its customers to use for building memory controllers
- Provides a means by which Xilinx can demonstrate high-speed DDR memory interoperability

This document describes the functional blocks within the ML361. It also provides various recommendations and requirements for usage of the board, including electrical requirements, logic analyzer requirements, and signal integrity issues. Simulation results using IBIS also are included.

Figure 1-1 shows a simplified block diagram of the ML361 memory interfaces.

Xilinx Target: Figure 1-1



ug060\_c1\_01\_012104

Figure 1-1: Simplified Block Diagram of Memory Board Interfaces

The ML361 demonstrates a 64-/72-bit interface to a 128 MByte, 200 MHz DDR SDRAM DIMM, a 72-bit interface to five 256 Mbit, 200 MHz DDR SDRAM components, and an additional 8-bit interface to a 256 Mbit, 200 MHz DDR SDRAM component on one of the top banks.

## Features

The key features of the ML361 are summarized below:

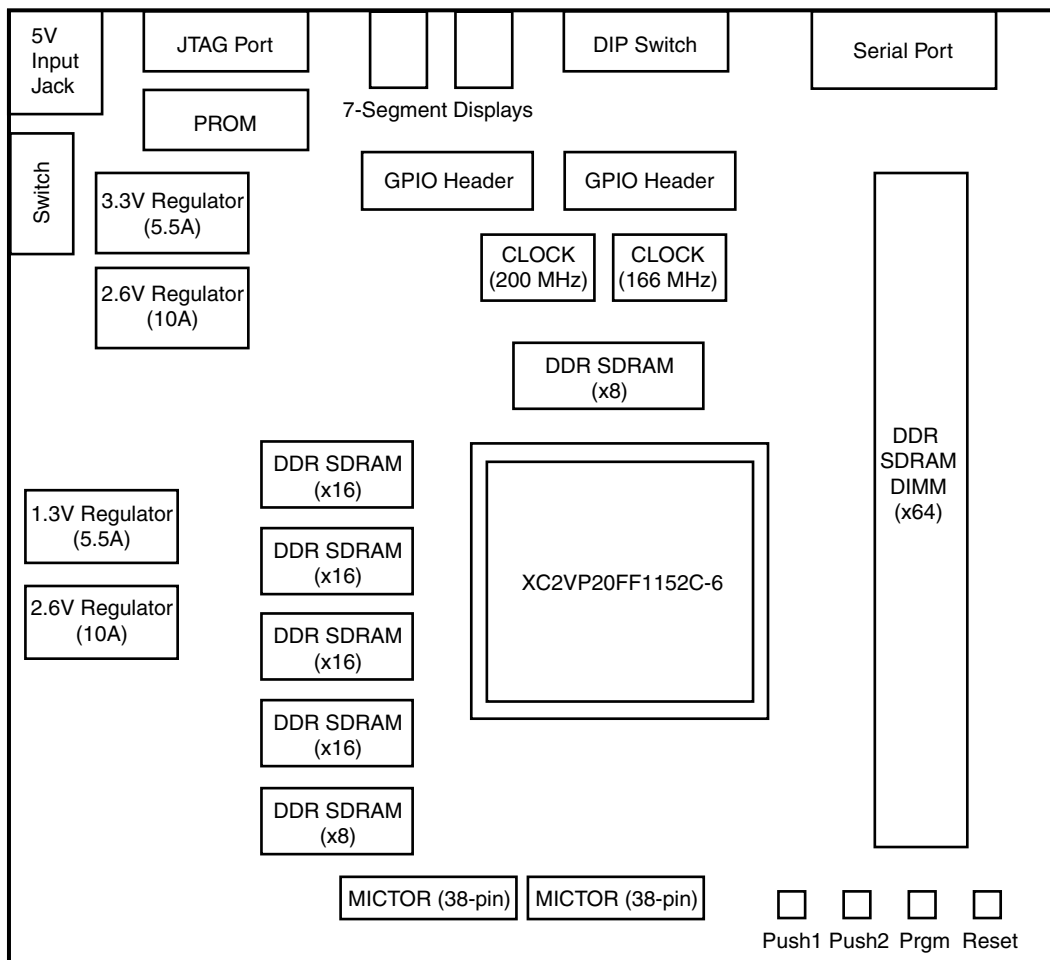
- One Virtex-II Pro FPGA (XC2VP20FF1152-6)
- One DDR SDRAM DIMM (MT4VDDT1664-AG-40BC3)
  - ◆ 128 MBytes
  - ◆ 64-/72-bit data interface
- Five DDR SDRAMs (four MT46V16M16TG-5B devices and one MT46V32M8TG-5B device)
  - ◆ 1.28 Gbits
  - ◆ 72-bit data interface
- One DDR SDRAM (MT46V32M8TG-5B)
  - ◆ 256 Mbits
  - ◆ 8-bit data interface
- Two separate controllers for each 72-bit memory interface
- 200 MHz interface
- The memory interfaces are located on the FPGA left/right interface and top I/O banks (banks 1, 2, 3, 6, and 7)

## Architecture

This chapter provides functional descriptions of the major blocks within the ML361 board design. For more detailed information on the design, refer to the schematics, which are located at <http://www.xilinx.com/bvdocs/userguides/ug060.zip>.

### ML361 Board Block Diagram

Figure 2-1 shows a block diagram of the ML361 board. Refer to the following section for additional information on the major blocks.



ug060\_c2\_01\_121703

Figure 2-1: ML361 Board Block Diagram

## Block Descriptions

This section describes the major blocks of the ML361 board.

### FPGA

The ML361 uses a Xilinx XC2VP20FF1152C-6 Virtex-II Pro device. This device is packaged in a 1152-pin BGA package with a -6 speed grade. Refer to [Appendix B, “FPGA Pinout,”](#) for a complete pinout of the Virtex-II Pro device.

### Memories

The ML361 board supports two types of memories: DDR SDRAM DIMM and DDR SDRAM.

#### DDR SDRAM DIMM (Banks 6 and 7)

The DDR SDRAM DIMM used on the ML361 board is a 184-pin, 200 MHz, unbuffered, non-ECC Micron MT4VDDT1664-AG-40BC3 device. This DIMM module has a 64-bit wide data interface. The board also has provisions to interface to a 72-bit wide DIMM.

#### DDR SDRAM Components (Banks 2 and 3)

The ML361 board contains five 200 MHz DDR SDRAM components that provide a 72-bit interface. These devices include four 16-bit Micron MT46V16M16TG-5B devices and one MT46V32M8TG-5B DDR SDRAM devices. They are packaged in 66-pin TSOP packages. They share a common address and control bus and have separate clocks and DQS/DQ signals.

#### DDR SDRAM Component (Bank 1)

The ML361 board contains one 8-bit Micron MT46V32M8TG-5B device on the top bank of the FPGA.

### RS232

The ML361 board provides an RS232 serial interface using a Texas Instruments MAX3221CDBR device. The maximum speed of this device is 250 Kb/s. The RS232 interface is accessible through a female DB9 RA connector.

### Clocks

The ML361 board contains 166 MHz and 200 MHz LVDS clock oscillators and connectors for external LVDS clock inputs.

#### 200 MHz LVDS Clock

The LVDS clock is a Pletronics LV1145BW-200.0M oscillator with a differential output. The oscillator runs at 200 MHz  $\pm$  50 PPM with an operating voltage of 2.5 V  $\pm$  5%. It is terminated at the FPGA with a 100 $\Omega$  resistor. FPGA pins J17 and H17 in Bank 1 serve as the CLK\_200\_LVDSP and CLK\_200\_LVDSN inputs, respectively.

## 166 MHz LVDS Test Clock

The LVDS test clock is a Pletronics SM7745DW-100.0M clock oscillator with a single-ended output. This oscillator runs at 166 MHz  $\pm$  50 PPM with an operating voltage of 2.5 V  $\pm$  5%. FPGA pins E17 and D17 in Bank 1 serve as the CLK\_166\_LVDSP and CLK\_166\_LVDSN inputs, respectively.

## SMA Clock

Two SMA connectors are provided for the input of an off-board differential clock. The traces from the SMAs are run as a pair to the FPGA where they are terminated with a 100 ohm resistor. AK18 serves as the CLK\_SMAP input, and AL18 serves as the CLK\_SMAN input for the SMA connector pair.

## User I/Os

This subsection describes the devices that connect to the User I/Os of the ML361 board.

### Mictor Connectors

The FPGA interfaces to two 38-pin Mictor connectors. They can be used to hook up to a logic analyzer. All signals from the FPGA to the connectors are matched closely. Refer to the Xilinx data sheets in [Appendix A, "Related Documentation,"](#) for more information.

### GPIO

The ML361 board contains 16 general-purpose I/Os (GPIOs), which are accessible through two 2 x 8 0.100" pin headers (see [Table 2-1](#) and [Table 2-2](#)). The even-numbered pins on each header are connected to ground. The GPIO header pins can be accessed through I/Os in Bank 0.

*Table 2-1: GPIO Header 1*

GPIO Pin #	FPGA I/O Pin
G00	F22
G01	E22
G02	E25
G03	D25
G04	H21
G05	D22
G06	D23
G07	D24

Table 2-2: GPIO Header 2

GPIO Pin #	FPGA I/O Pin
G08	D30
G09	D29
G10	K23
G11	J23
G12	H22
G13	G22
G14	D26
G15	C26

## DIP Switch

One eight-position DIP switch is connected to the FPGA I/Os as shown in [Table 2-3](#). These switches can be used to externally pull up or pull down any signal on the FPGA.

Table 2-3: DIP Switch Connections

DIP Switch Input	FPGA I/O Pin #
DIP1	G26
DIP2	H25
DIP3	G25
DIP4	J25
DIP5	K24
DIP6	J24
DIP7	F26
DIP8	E26

## Seven-Segment Displays

Two seven-segment displays connect to the FPGA I/Os (see [Table 2-4](#) and [Table 2-5](#)). The red displays are active Low. The decimal points are not connected.

Table 2-4: Display 1

Display Input	FPGA I/O Pin #
Display1A	C21
Display1B	E21
Display1C	F21
Display1D	J20
Display1E	K20



Table 2-4: Display 1

Display Input	FPGA I/O Pin #
Display1F	C24
Display1G	D24

Table 2-5: Display 2

Display Input	FPGA I/O Pin #
Display2A	D20
Display2B	D21
Display2C	F20
Display2D	G20
Display2E	K19
Display2F	L19
Display2G	C22

## LEDs

Four green LEDs connect to the FPGA I/Os as indicated in Table 2-6. The LEDs are active Low.

Table 2-6: LED Connections to FPGA

LED #	FPGA I/O Pin #
LED1	L18
LED2	K18
LED3	G18
LED4	F18

## Push Buttons

The ML361 board contains four momentary push buttons. Their functions are as follows:

- Program the FPGA
- Reset the board
- User function 1
- User function 2

## Grounded I/Os

Unused I/Os are connected to GND in all FPGA banks. However, all memory banks have eight unused I/Os connected to GND through 0Ω resistors. These can be depopulated when needed for test purposes. Care must be taken to not drive any unused I/Os connected to GND.

## Power

### Power Distribution

The ML361 board uses a 5V input voltage source to generate all the on-board voltages (1.3V, 1.5V, 2.6V, and 3.3V, and the 2.5V for the MGTs)

### Input Voltage

The input voltage is specified at 5 V @ 6.5 A. The recommended power supply is a CUI Inc. DTS050650UTC-PSP-SZ. The jack used is a 4-pin barrel jack, CUI stack PJ-002A-SMT. The slide switch is a CW Industries G1123-0009. This power input has alternate input solder pads.

### 3.3 V Generation

The Texas Instruments PTH05000WAH voltage regulator generates the 3.3 V @ 5.5 A power. This power input has alternate input solder pads.

### 2.6 V Generation

The Texas Instruments PTH05010WAS voltage regulator generates the 2.6 V @ 10 A power. This regulator provides 2.5 V<sub>out</sub> with  $\pm 10\%$  trim. This power input has alternate input solder pads.

### 1.5 V Generation

The Texas Instruments PTH05000WAH voltage regulator generates the 1.5 V @ 5.5 A power. This power input has alternate input solder pads.

### 1.3 V Generation

The Texas Instruments PTH05000WAH voltage regulator generates the 1.3 V @ 1.5 A power.

### Linear Regulators for the MGTs

The Texas Instruments TPS78625 voltage regulator generates 2.5 V @ 1.5 A power for the Multi Gigabit Transceivers (MGTs).

## FPGA Configuration

The Virtex-II Pro FPGA can be programmed through either the JTAG interface or three on-board PROMs.

### JTAG

Two headers are used for JTAG: a standard header and a parallel-IV header.

#### Standard Header

The standard JTAG header is a 1 x 7 0.100" RA header.

#### Parallel-IV Header

The parallel-IV headers is a 2 x 7 2 mm RA shrouded header.

## PROMs

The ML361 board contains XCF04S PROMs that can be used to program the Virtex-II Pro FPGA. The PROM operates with a 3.3 V core voltage and a 2.5 V I/O voltage.



## Electrical Requirements

### Power Consumption

Table 3-1 lists the operating voltages, maximum currents, and power consumption used by the ML361 board devices. Refer to [Appendix A, "Related Documentation,"](#) for more information on the source material.

Table 3-1: ML361 Power Consumption

Device	Quantity	Voltage (V)	Current (mA)	Power (W)	Source
<b>Total Available Power</b>					
Power Supply	1	5	6500	32.5	
<b>FPGA Power (Based on Design)</b>					
FPGA (XC2VP20-6 FF1152)	1			6.873	Power Estimator Tool
<b>Board Power</b>					
Static Power-on Termination Resistors (50Ω)	375	1.3	16.2	4.92	<i>Virtex-II Pro User Guide</i> (SSTL2 current specification)
DDR SDRAM (72-bit interface)	5	2.6	260	3.38	Micron DDR SDRAM Data Sheet
DDR SDRAM (8-bit interface)	1	2.6	260	0.676	
DDR SDRAM DIMM	1	2.6	1040	2.704	Micron DDR SDRAM DIMM Data Sheet
200 MHz LVDS Clock Oscillator	1	3.3	40	0.132	Pletronics LV1145B-200 Data Sheet
166 MHz LVDS Clock Oscillator	1	3.3	40	0.132	Pletronics LV1145B-166 Data Sheet
PROMs (XCF04SV020C)	3	2.6	25	0.2	Estimated
	3	3.3	25	0.25	Estimated
8-pin GPIO Header	2	2.6	160	0.416	Average 10 mA * 16 pins
Seven Segment Display	2	2.6	86	0.224	Fourteen 130Ω loads
LEDs	9	2.6	25	0.585	Nine 130Ω loads
DIP Switch	1	2.6	6	0.016	Eight 3.3 kΩ pull-ups
RS232 Serial Port	1	3.3	40	0.132	TI MAX3221 Data Sheet
<b>Worst Case Power Consumption:</b>				<b>20.64</b>	

## FPGA Internal Power Budget

The following tables show the power consumption values inside the FPGA based on the complete DDR design. These results are derived using the Xilinx Power Estimator tool. Block Select RAM, Block Multiplier, Processor, and MGT Power tables are not included in this section as they are not used in this application.

- [Table 3-2, “XC2VP20FF1152 Estimated Power Consumption,” page 22](#)
- [Table 3-3, “XC2VP20FF1152 Temperature Specifications,” page 22](#)
- [Table 3-4, “Device Quiescent Power,” page 22](#)
- [Table 3-5, “CLB Logic Power,” page 23](#)
- [Table 3-6, “Digital Clock Manager Power,” page 23](#)
- [Table 3-7, “Input/Output Power,” page 24](#)

**Table 3-2: XC2VP20FF1152 Estimated Power Consumption**

Parameter	Value	Units
Total Estimated Design Power	6873	mW
Estimated Design VCC <sub>INT</sub> 1.5 V Power	3811	mW
Estimated Design VCC <sub>AUX</sub> 2.5 V Power	417	mW
Estimated Design VCCO 3.3 V Power	0	mW
Estimated Design VCCO 2.5 V Power	2645	mW
Estimated Design VCCO 1.8V Power	0	mW
Estimated Design VCCO 1.5 V Power	0	mW
Estimated Design VCCO 1.2 V Power	0	mW
Estimated Design VCC <sub>AUXRX</sub> 2.5 V Power	0	mW
Estimated Design VCC <sub>AUXTX</sub> 2.5 V Power	0	mW
Estimated Design VT <sub>RX</sub> 2.5 V Power	0	mW
Estimated Design VT <sub>TX</sub> 2.5 V Power	0	mW

**Table 3-3: XC2VP20FF1152 Temperature Specifications**

Parameter	Value	Units
Ambient Temperature	25	•C
Air Flow	0	LFM
Junction Temperature	107	•C

**Table 3-4: Device Quiescent Power**

VCC <sub>INT</sub> Subtotal (mW)	VCC <sub>AUX</sub> Subtotal (mW)
450	417

**Table 3-5: CLB Logic Power**

Name	Frequency (MHz)	Total Number of CLB Slices	Total Number of Flip/Flop or Latches	Total Number of Shift Register LUTs	Total Number of Select RAM LUTs	Average Toggle Rate %	Amount of Routing Used	VCC <sub>INT</sub> Subtotal (mW)
User Module 1	200	2597	2603	0	1088	40%	High	2439
User Module 2	0	0	0	0	0	0%	Low	0
User Module 3	0	0	0	0	0	0%	Low	0
User Module 4	0	0	0	0	0	0%	Low	0
User Module 5	0	0	0	0	0	0%	Low	0
User Module 6	0	0	0	0	0	0%	Low	0
User Module 7	0	0	0	0	0	0%	Low	0
User Module 8	0	0	0	0	0	0%	Low	0
User Module 9	0	0	0	0	0	0%	Low	0
User Module 10	0	0	0	0	0	0%	Low	0
User Module 11	0	0	0	0	0	0%	Low	0
User Module 12	0	0	0	0	0	0%	Low	0
<b>Total</b>								<b>2439</b>

**Table 3-6: Digital Clock Manager Power**

Name	Clock Input Frequency (MHz)	DCM Frequency Mode	VCC <sub>INT</sub> Subtotal (mW)
User DCM 1	200	Low	6
User DCM 2	200	Low	6
User DCM 3	0	Low	0
User DCM 4	0	Low	0
User DCM 5	0	Low	0
User DCM 6	0	Low	0
User DCM 7	0	Low	0
User DCM 8	0	Low	0
User DCM 9	0	Low	0
User DCM 10	0	Low	0
User DCM 11	0	Low	0
User DCM 12	0	Low	0
<b>Total</b>			<b>12</b>

Table 3-7: Input/Output Power

Name	Frequency (MHz)	I/O Standard Type	Total Number of Inputs	Total Number of Outputs	Average IOB Toggle Rate %	Average Output Enable Rate %	Average Output Load (pF)	IOB Registers	VCC <sub>INT</sub> Subtotal (mW)	VCCO Subtotal (mW)
Jpheader	200	LVC MOS25_12	0	16	25%	100%	0	SDR	2	30
ddr_dq	200	SSTL2_II	138	138	80%	50%	5	DDR	462	877
ddr_dqs	2000	SSTL2_II	18	18	80%	50%	5	DDR	335	363
ddr_address	200	SSTL2_II	0	15	25%	100%	3	SDR	1	106
ddr_control	200	SSTL2_II	0	5	25%	100%	3	SDR	0	35
dimmem_address	200	SSTL2_I_DCI	0	15	25%	100%	12	SDR	13	157
dimmem_control	200	SSTL2_I_DCI	0	4	50%	100%	12	SDR	12	96
ddr_clks	200	SSTL2_II	0	2	100%	100%	3	DDR	0	42
Display	200	LVC MOS25_12	0	14	6%	100%	0	SDR	1	6
dimmem_control_1	200	SSTL2_II	0	3	50%	100%	12	SDR	0	28
ddr_dm	200	SSTL2_II	0	17	10%	100%	5	SDR	2	100
dimmem_clks	200	SSTL2_II	0	6	100%	100%	12	SDR	1	82
top_dq	200	SSTL2_II_DCI	8	8	80%	50%	5	DDR	39	366
top_dqs	200	SSTL2_II_DCI	1	1	80%	50%	5	DDR	15	103
top_address	200	SSTL2_I_DCI	0	15	25%	100%	5	SDR	13	153
top_control	200	SSTL2_I_DCI	0	5	25%	100%	5	SDR	12	95
<b>Total</b>									<b>910</b>	<b>2645</b>



## Signal Integrity Recommendations and Simulations

This chapter provides the following information:

- Summary of the termination schemes for various signals (“[Termination and Transmission Line Summaries](#),” page 25)
- Summary of the observed duty cycles for all signals in the IBIS simulations (“[Duty Cycle Summary](#),” page 27)
- IBIS simulations and duty cycle measurements (“[IBIS Simulations](#),” page 29)

### Termination and Transmission Line Summaries

[Table 4-1](#) summarizes the terminations for the five DDR SDRAM components at the FPGA and at memory.

**Table 4-1: DDR SDRAM Terminations**

No.	Signal	Drivers at the FPGA	Termination at FPGA	Termination at Memory
1	Data (DQ)	SSTL2_C2	50Ω pull up to 1.3 V	50Ω pull-up to 1.3 V
2	Data Strobe (DQS)	SSTL2_C2	50Ω pull up to 1.3 V	50Ω pull-up to 1.3 V
3	Data Mask (DM)	SSTL2_C2	50Ω pull up to 1.3 V	50Ω pull-up to 1.3 V
4	Clock (CK, CKn)	SSTL2_C2	50Ω pull up to 1.3 V	50Ω pull-up to 1.3 V
5	Address (A, BA)	SSTL2_C2	No termination	50Ω pull-up to 1.3 V after the last component
6	Control (RASn, CASn, WEn, CSn, CKE)	SSTL2_C2	No termination	50Ω pull-up to 1.3 V after the last component

[Table 4-2](#) summarizes the terminations for the DIMM at the FPGA and at memory.

**Table 4-2: DIMM Terminations**

No.	Signal	Drivers at the FPGA	Termination at FPGA	Termination at Memory
1	Data (DQ)	SSTL2_C2	50Ω pull-up to 1.3 V	50Ω pull-up to 1.3 V
2	Data Strobe (DQS)	SSTL2_C2	50Ω pull-up to 1.3 V	50Ω pull-up to 1.3 V
3	Data Mask (DM)	SSTL2_C2	50Ω pull-up to 1.3 V	50Ω pull-up to 1.3 V

Table 4-2: DIMM Terminations

No.	Signal	Drivers at the FPGA	Termination at FPGA	Termination at Memory
4	3 pairs of Clocks (CK, CKn)	SSTL2_C2	50Ω pull-up to 1.3 V	50Ω pull-up to 1.3 V
5	Address (A, BA)	SSTL2_C2_DCI	No termination	No termination
6	Control (RASn, CASn, WEn, CSn, CKE and others)	SSTL2_C2_DCI	No termination	No termination

## Terminations and Transmission Lines for DDR Components

### Data and Clock Signals (DQ, DQS, DM, CLK)

For these DDR signals, the terminations at the FPGA and memory consist of a 50Ω parallel termination pulled up to 1.3 V.

Use 50Ω transmission lines with less than  $\pm 1\%$  tolerance on the transmission line impedance. The recommendations for the transmission line lengths are as follows:

- All these data and clock signals are point-to-point from the FPGA to each DDR component. All signals going to one individual DDR SDRAM component need to be matched with respect to each other with a  $\pm 2\%$  tolerance.
- All signals going to the first component are matched to a trace length of 2.8 inches with a  $\pm 2\%$  tolerance. The 2.5 inch requirement includes the FPGA internal package skew (available on the pinout table) and the skew between the ball of the FPGA to the resistor pack as well as the length of the actual trace.
- The trace length variation on these signals across the five DDR components is kept as small as possible to enable data capture while also ensuring they fall within the address window. The trace lengths on all five DDR components are: 2.8 inches, 2.8 inches, 3.5 inches, 3.8 inches, and 3.8 inches. All signals corresponding to the same DDR component are matched as close as  $\pm 1\%$  of the above mentioned trace lengths.

Microstrip is used to model the transmission lines in the IBIS simulations.

### Address and Control Signals (A, BA, RASn, CASn, WEn, CSn, CKE)

For the address and control signals, no termination is required at the FPGA. At memory, a 50Ω resistor pulled up to 1.3 V at the end of the daisy chain is required (after the last DDR component).

Use 50Ω transmission lines with  $\pm 5\%$  tolerance from the FPGA to all the memory components. The recommendations for the transmission line lengths are as follows:

- All the signals are routed in a daisy chain fashion.
- There is a maximum of 2.5 inch trace with  $\pm 2\%$  tolerance from the FPGA to the first DDR component. The 2.5 inch requirement includes the FPGA internal package skew (that is available on the pinout table) and the skew between the ball of the FPGA to the resistor pack as well as the length of the actual trace.
- 0.6 inches of distance with  $\pm 2\%$  tolerance is used in the trace length calculations below between the individual components. Ideally, straight line routing is desired. During placement, the components are placed as close as 0.5 inches or lesser by straight line routing, if possible. The main requirement is that all signals going to each DDR component must be matched by  $\pm 2\%$  tolerance.

- There is a total of 4.9 inches of trace from the FPGA to the last component assuming the DDR memory components are 0.6 inch apart.

Microstrip is used to model the transmission lines for the first DDR component. All other DDR components use Buried Microstrip to model the transmission lines.

## Terminations and Transmission Lines for the DIMM

### Data and Clock Signals (DQ, DQS, DM, CLK)

For these DIMM signals, the terminations at the FPGA and memory consist of a 50Ω parallel termination pulled up to 1.3 V.

50Ω transmission lines are used with less than ± 1% tolerance on the transmission line impedance. The transmission line lengths are as follows:

- There is a 65 mm trace length from FPGA to memory with ± 0.5 mm tolerance.
- A maximum of 1 inch tolerance is allowed to include the FPGA internal package skew and the skew between the ball of the FPGA to the resistor pack. Package deskew is necessary if the 1 inch tolerance is not met.

### Address and Control Signals (A, BA, RASn, CASn, WEn, CSn, CKE)

For the address and control signals, no termination is required at the FPGA or DIMM.

Use 50Ω transmission lines with less than ± 5% tolerance on the transmission line impedance. The recommendations for the transmission line lengths are as follows:

- There must be a 65 mm trace length from FPGA to memory with ± 5 mm tolerance.
- Use a maximum of 1 inch tolerance to include the FPGA internal package skew and the skew between the ball of the FPGA to the resistor pack. Package deskew is necessary if the 1 inch tolerance is not met.

## Duty Cycle Summary

Table 4-3 summarizes the duty cycle measurements taken from prelayout simulations on 50Ω transmission lines. Refer to “IBIS Simulations,” page 29 for more simulation results.

Table 4-3: Duty Cycle Summary

No.	Signal	DDR Component	Case	Duty Cycle Measured at Memory(%)	Duty Cycle Measured at FPGA (%)
1	Address/control	Last component (farthest from FPGA)	Typical	49.22/50.92	NA
			Slow weak	49.22/50.63	NA
			Fast strong	49.22/51.2	NA
2	Address/control	First component (closest to FPGA)	Typical	48.94/51.2	NA
			Slow weak	49.22/51.48	NA
			Fast strong	48.66/51.2	NA

Table 4-3: Duty Cycle Summary

No.	Signal	DDR Component	Case	Duty Cycle Measured at Memory(%)	Duty Cycle Measured at FPGA (%)
3	Address/control	Middle component	Typical	49.23/51.49	NA
			Slow weak	49.22/50.64	NA
			Fast strong	48.94/51.2	NA
4	Clock	Last component	Typical	48.1/52.04	NA
			Slow weak	48.66/51.48	NA
			Fast strong	48.1/51.48	NA
5	Data	Last component	Typical	47.24/52.62	48.64/51.78
			Slow weak	47.52/52.06	49.52/50.64
			Fast strong	46.4/52.9	48.38/51.76

## IBIS Simulations

This section summarizes various simulations run on the Memory Board using IBIS. It defines the test conditions and provides color-coded screen captures of the results. The resulting signal duty cycles are given also.

The simulations have been divided into the following categories:

1. Data Signal Simulations
  - a. Data Signals from the FPGA to the Last Memory Component
    - Typical Case
    - Slow Weak Case
    - Fast Strong Case
    - Eye Diagram
  - b. Data Signals from the Last Memory Component to the FPGA
    - Typical Case
    - Slow Weak Case
    - Fast Strong Case
    - Eye Diagram
2. Clock Signal Simulations
  - a. Clock Signals from the FPGA to the Last Memory Component
    - Typical Case
    - Slow Weak Case
    - Fast Strong Case
    - Eye Diagram
3. Address and Control Signal Simulations
  - a. Address and Control Signals from the FPGA to the First/Last/Middle Memory Component
    - All Memory Components (Typical Case)
    - First DDR Component (Typical, Slow Weak, Fast Strong Cases)
    - Last DDR Component (Typical, Fast Strong, Slow Weak Cases)
    - Middle DDR Component (Typical, Slow Weak, Fast Strong Cases)
4. Typical Case Simulations with 10% Tolerance for:
  - a. Data Signals
    - Data Signals from the Last DDR Memory to the FPGA with 45 $\Omega$  Transmission Lines (Typical)
    - Data Signals from the Last DDR Memory to the FPGA with 55 $\Omega$  Transmission Lines (Typical)
    - Data Signals from the FPGA to the Last DDR Memory with 45 $\Omega$  Transmission Lines (Typical)
    - Data Signals from Memory to the FPGA with 55 $\Omega$  transmission lines (Typical)
  - b. Clock Signals
    - Clock Signals with 45 $\Omega$  Transmission Lines (Typical)
    - Clock Signals with 55 $\Omega$  Transmission Lines (Typical)

- c. Address and Control Signals
  - Address and Control Signals with 45 $\Omega$  Transmission Lines Measured at First DDR Component (Typical)
  - Address and Control Signals with 55 $\Omega$  Transmission Lines Measured at First DDR Component (Typical)

## Notes on the Simulation Results

The provided screen captures show the results of each simulation. The signals in these screen captures are color-coded as follows:

- Red signal – at FPGA
- Yellow signal – at memory

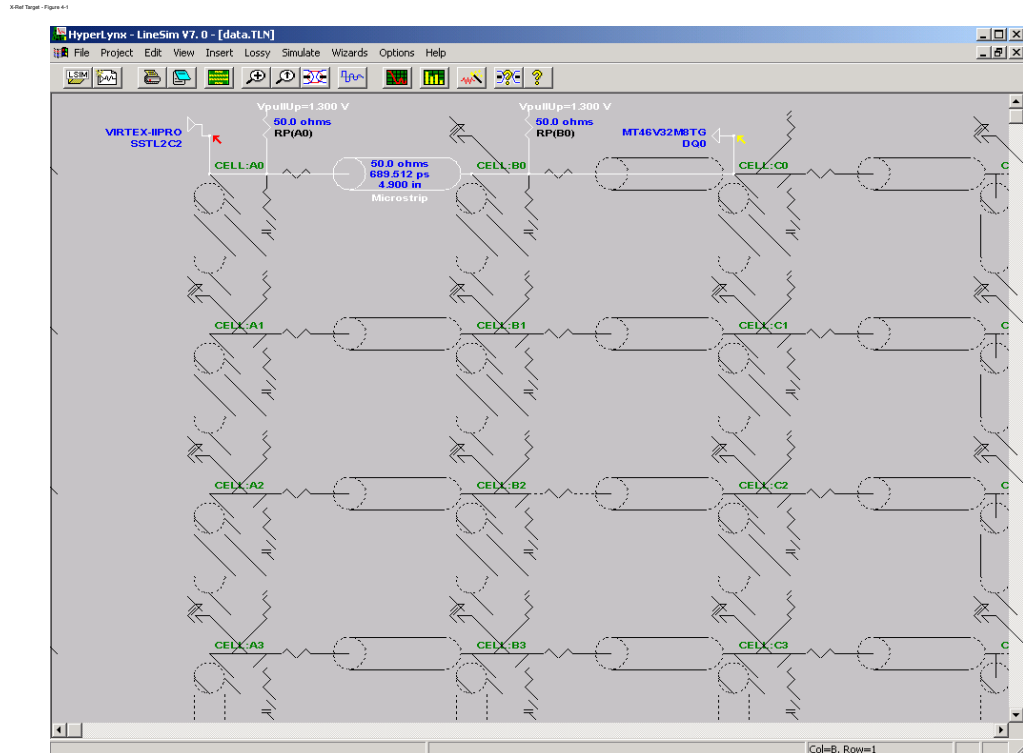
The two horizontal yellow lines are  $V_{\text{ref}} \pm 100 \text{ mV}$  where  $V_{\text{ref}} = 1.3 \text{ V}$ .

## Data Signal Simulations

All data signal simulations below have the following test conditions for typical, slow weak, and fast strong cases:

- Topology for data signals: 50Ω Transmission lines
- At memory (yellow signal): 50Ω parallel termination pulled up to 1.3 V
- At FPGA (red signal): 50Ω parallel termination pulled up to 1.3 V (SSTL2C2 drivers at FPGA).

Figure 4-1 shows the data signal terminations.



ug060\_c5\_01\_091003

Figure 4-1: Data Signal Terminations

## Data Signals from the FPGA to Memory (SSTL2\_C2 at FPGA)

The simulations in this subsection test the data signals from the FPGA to memory. Simulations were performed for the following cases: typical, slow weak, fast strong. An eye diagram is provided also.

### Typical Case Simulation for Data Signals from the FPGA to the Last DDR Component

For the typical case simulation, the resulting duty cycle is 47.24/52.62. [Figure 4-2](#) shows the simulation screen capture for the typical case.

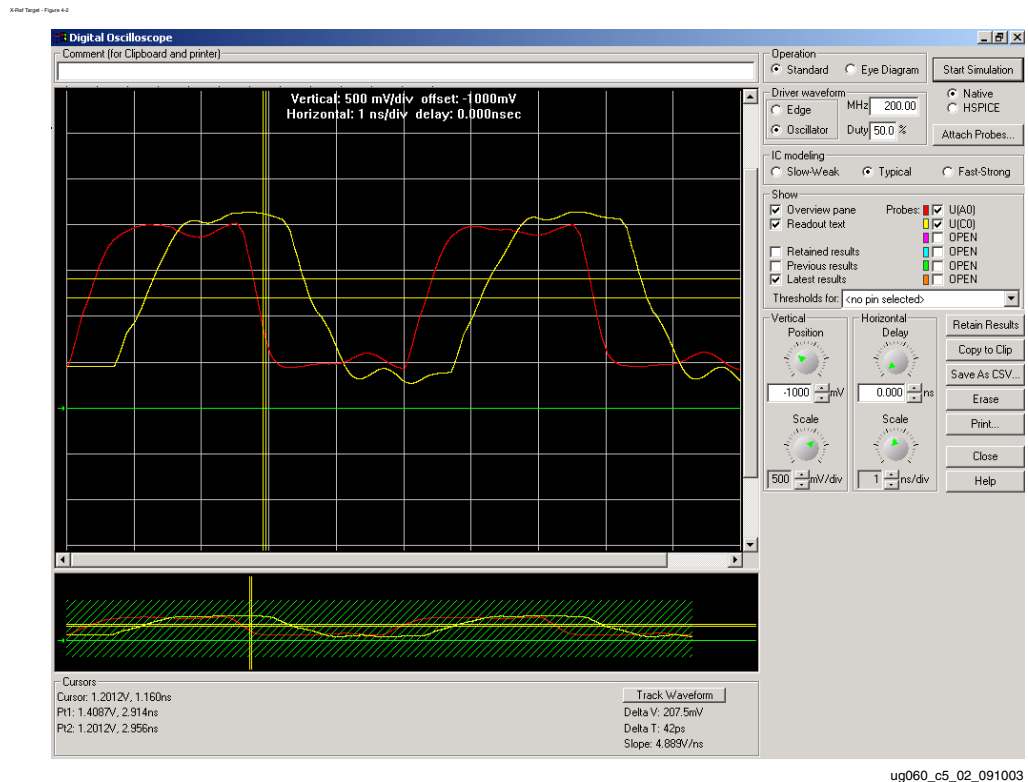


Figure 4-2: Data Signal from FPGA to Memory (Typical Case)



Slow Weak Corner Case for Data from the FPGA to the Last DDR Component

For the slow weak case simulation, the resulting duty cycle is 47.52/52.06. [Figure 4-3](#) shows the simulation screen capture for this case.

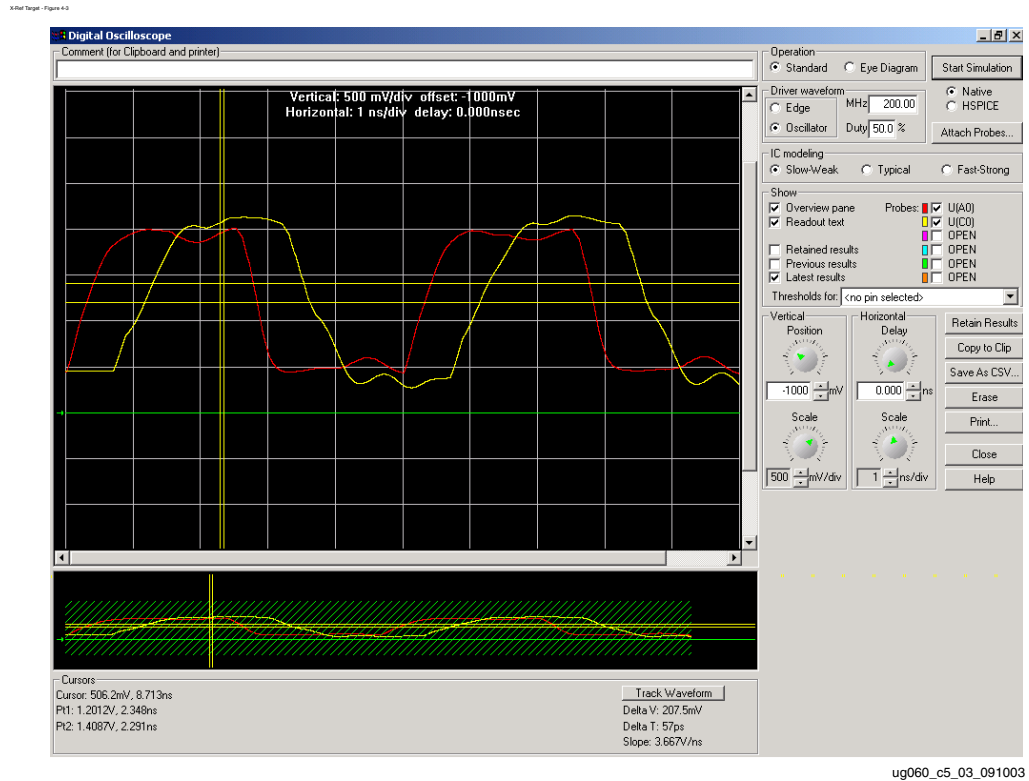
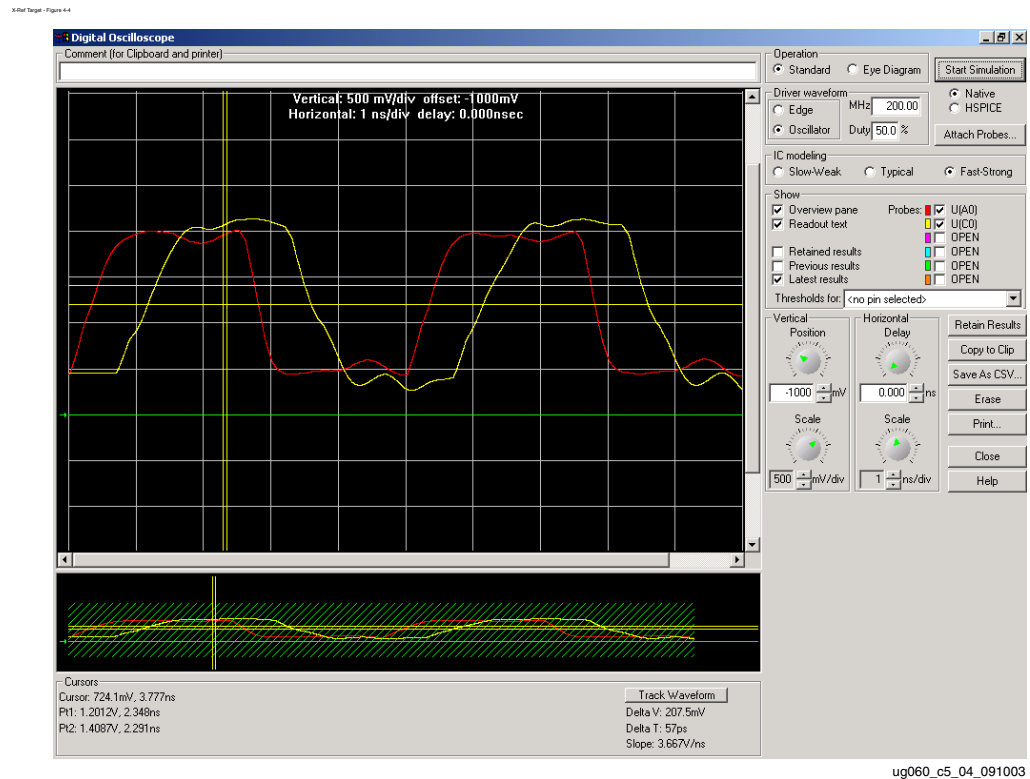


Figure 4-3: Data Signal from FPGA to Memory (Slow Weak Case)

### Fast Strong Case for Data Signals from the FPGA to the Last DDR Component

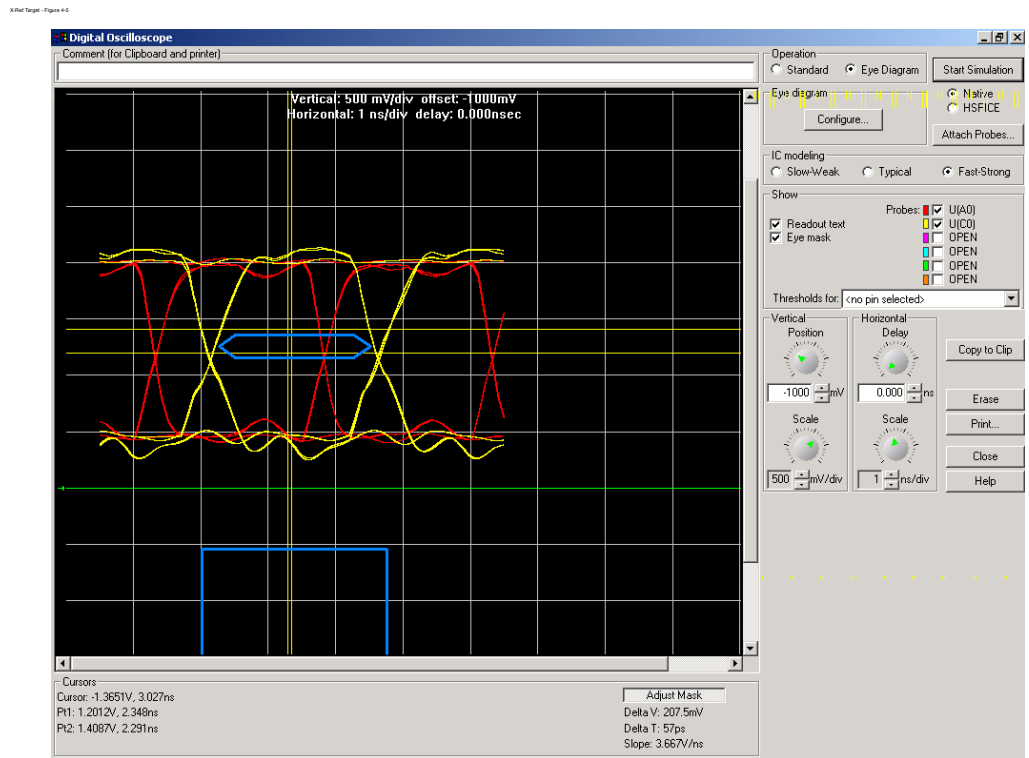
For the fast strong case simulation, the resulting duty cycle is 46.4/52.9. [Figure 4-4](#) shows the simulation screen capture for this case.



**Figure 4-4: Data Signal from FPGA to Memory (Fast Strong Case)**

### Eye Diagram

Figure 4-5 shows the eye diagram for the data signals from the FPGA to the last memory component.



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Figure 4-5: Eye Diagram for Data from the FPGA to Last Memory Component

## Data Signals from the Last Memory to the FPGA: Measured at FPGA

The simulations in this subsection test the data signals from the last memory to the FPGA. Simulations were performed for the following cases: typical, slow weak, and fast strong. An eye diagram is provided also.

### Typical Case for Data from the Last DDR Memory Device to the FPGA

For the typical case simulation, the resulting duty cycle is 48.64/51.78. [Figure 4-6](#) shows the simulation screen capture for this case.

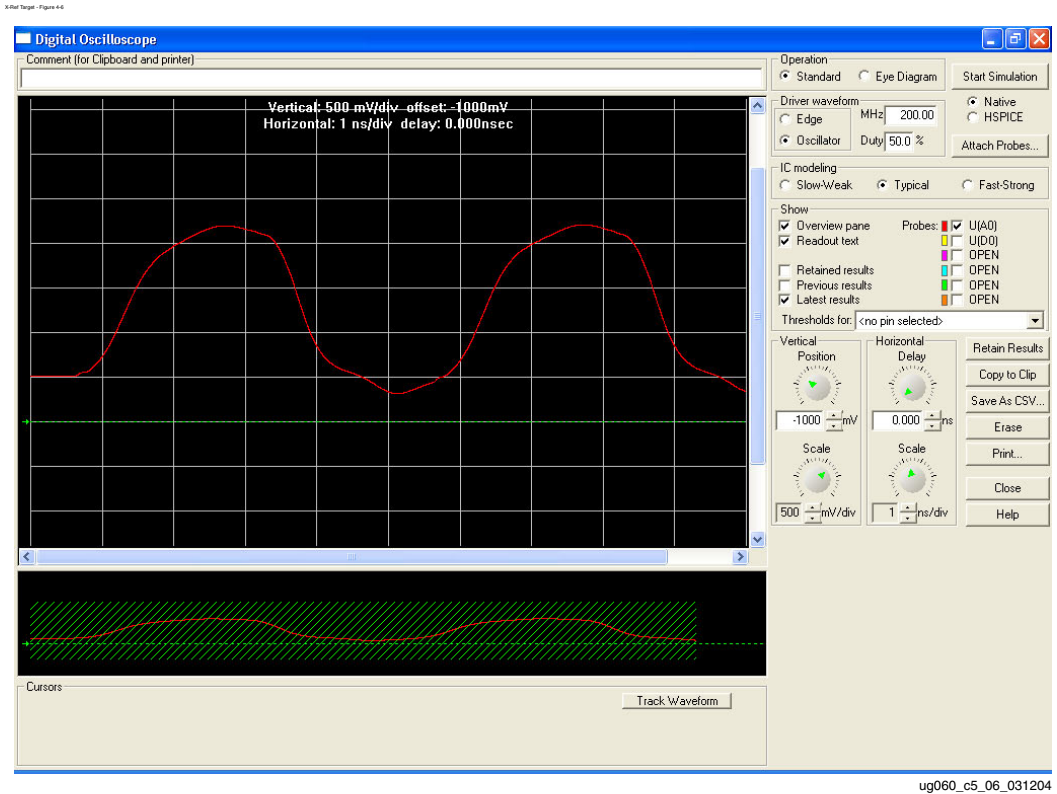
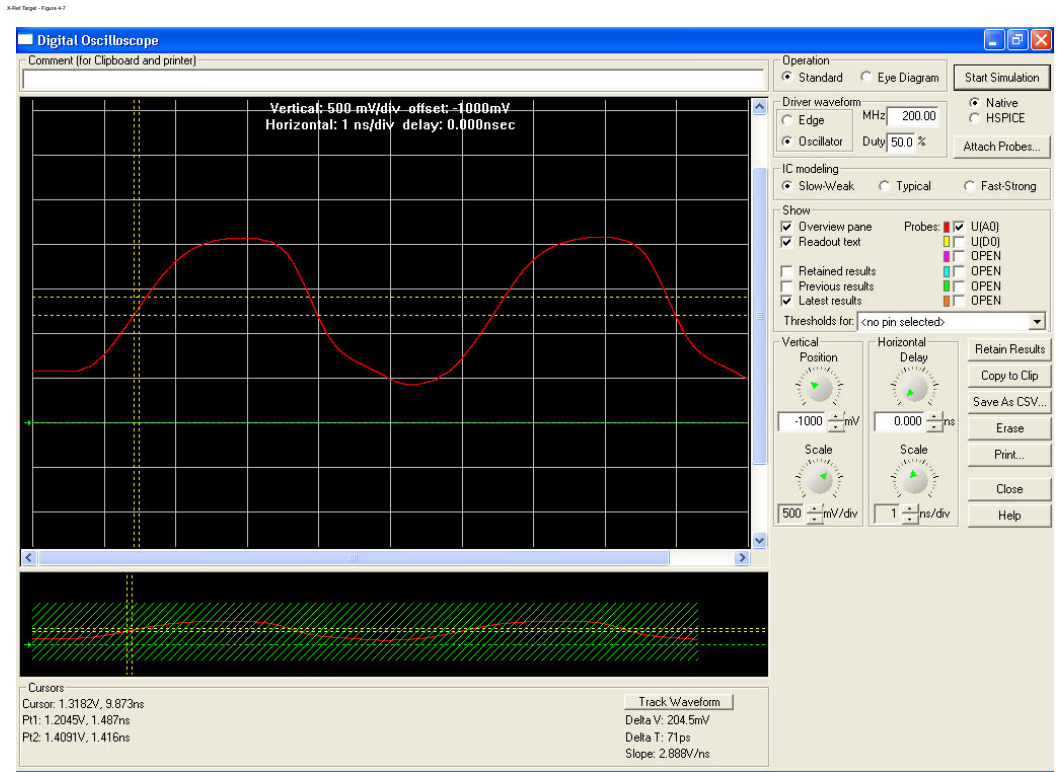


Figure 4-6: Data Signal from Last Memory at FPGA (Typical Case)

Slow Weak Corner Case for Data Signals from the Last DDR Memory to the FPGA

For the slow weak case simulation, the resulting duty cycle is 49.52/50.64. [Figure 4-7](#) shows the simulation screen capture for this case.

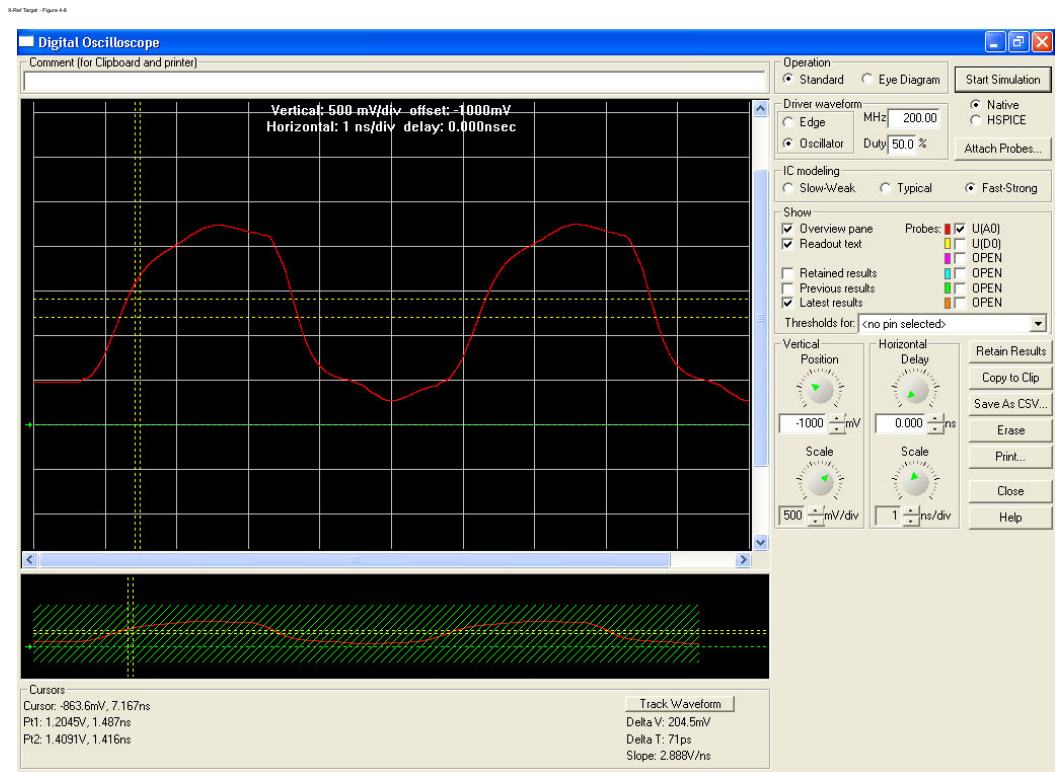


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Figure 4-7: Data Signal from Last Memory at FPGA (Slow Weak Corner Case)

### Fast Strong Corner Case for Data from Memory to the FPGA

For the fast strong case simulation, the resulting duty cycle is 48.38/51.76. [Figure 4-8](#) shows the simulation screen capture for this case.

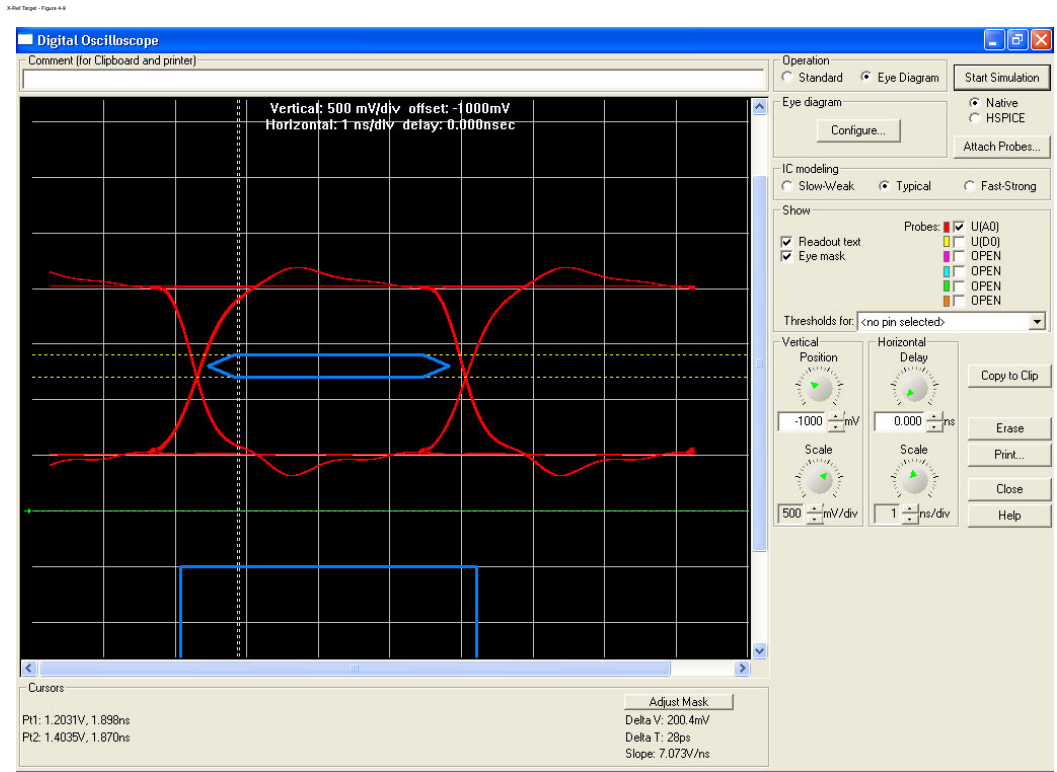


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**Figure 4-8: Data Signal from Memory at FPGA (Fast Strong Corner Case)**

### Eye Diagram for Data Signal Measured at the FPGA

Figure 4-9 shows the eye diagram for the data signals from the FPGA to the last memory component.



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Figure 4-9: Eye Diagram for Data at the FPGA to the Last Memory Component

## Clock Signal Simulations

The simulations in this subsection test the unidirectional clock signals from the FPGA to memory. Simulations were performed for the following cases: typical, slow weak, and fast strong. An eye diagram is provided also.

All clock signal simulations below have the following test conditions for typical, slow weak, and fast strong cases:

- Topology for clock signals: 50Ω transmission lines
- At memory (yellow signal): 50Ω parallel termination pulled up to 1.3 V
- At FPGA (red signal): 50Ω parallel termination pulled up to 1.3 V (SSTL2C2 drivers at FPGA).

Figure 4-10 shows the clock signal terminations.

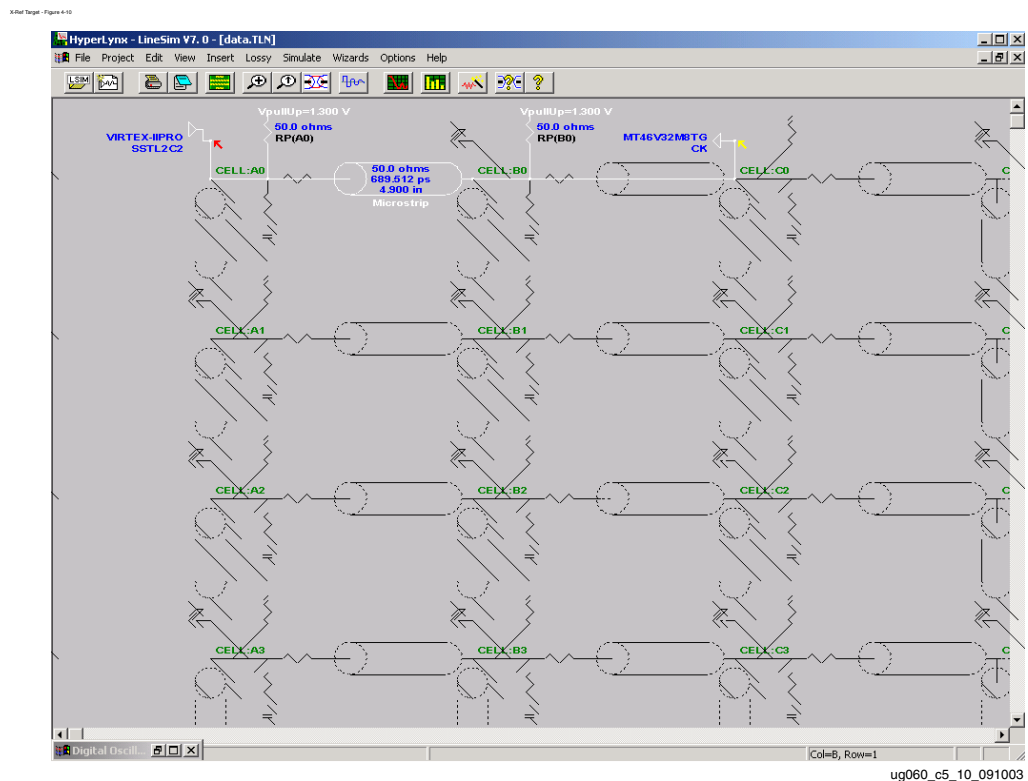


Figure 4-10: Clock Signal Terminations



### Typical Case for Clock Signals

For the typical case simulation, the resulting duty cycle is 48.1/52.04. Figure 4-11 shows the simulation screen capture for this case.

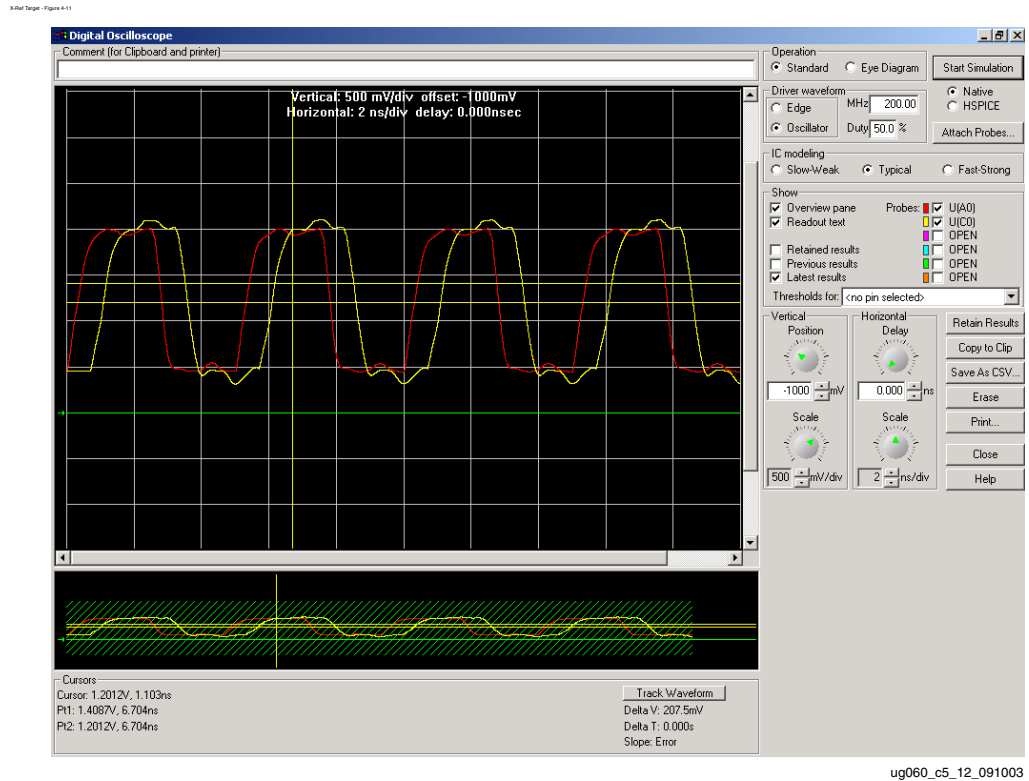


Figure 4-11: Clock Signal from FPGA to Memory (Typical Case)

### Slow Weak Case for Clock Signals

For the slow weak case simulation, the resulting duty cycle is 48.66/51.48. [Figure 4-12](#) shows the simulation screen capture for this case.

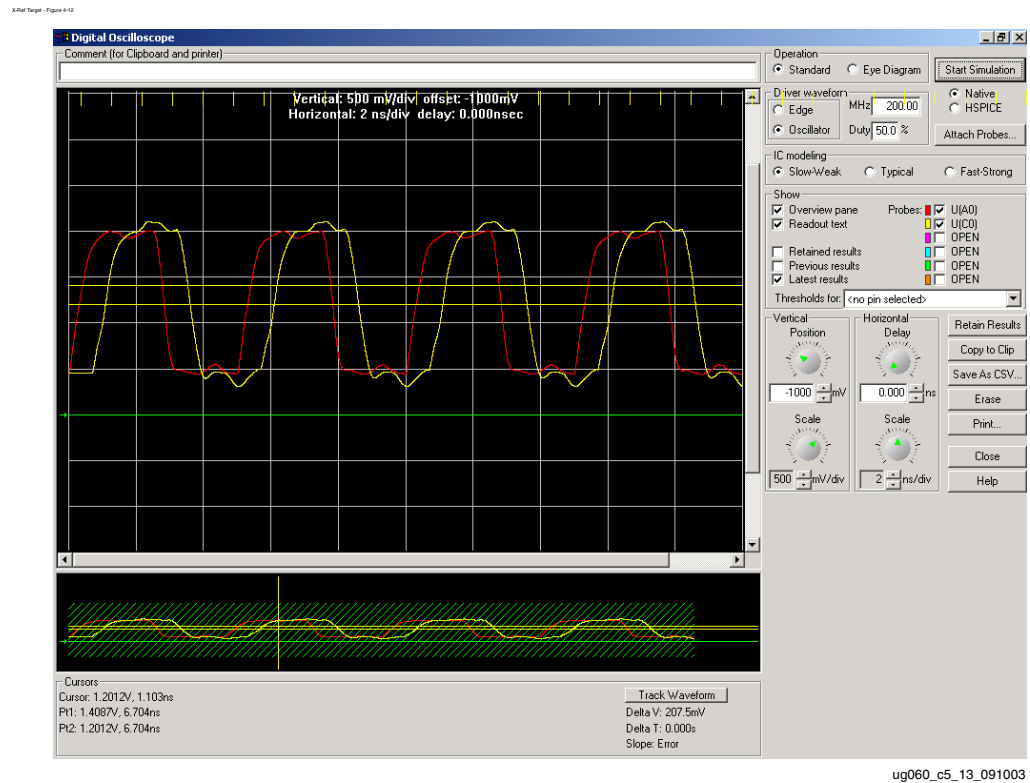
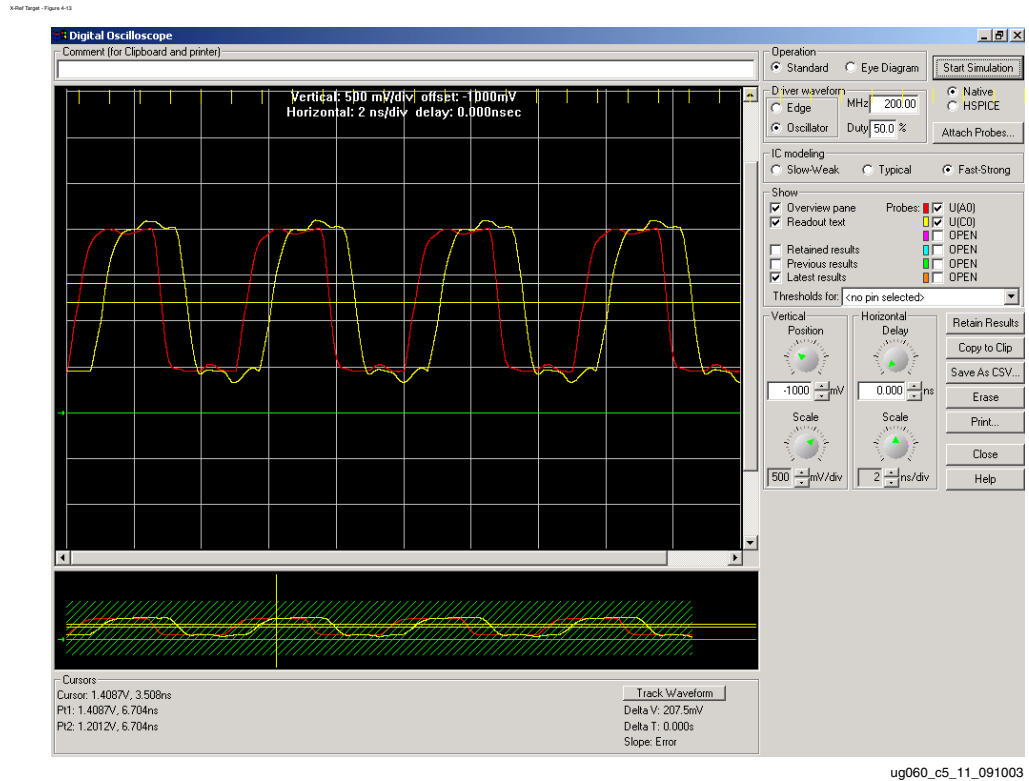


Figure 4-12: Clock Signal from FPGA to Memory (Slow Weak Case)

### Fast Strong Case for Clock Signals

For the fast strong case simulation, the resulting duty cycle is 48.1/51.48. [Figure 4-13](#) shows the simulation screen capture for this case.



**Figure 4-13: Clock Signal from FPGA to Memory (Fast Strong Case)**

## Eye Diagram of Clock Signals at Memory

Figure 4-14 shows the eye diagram for the clock signals at memory.

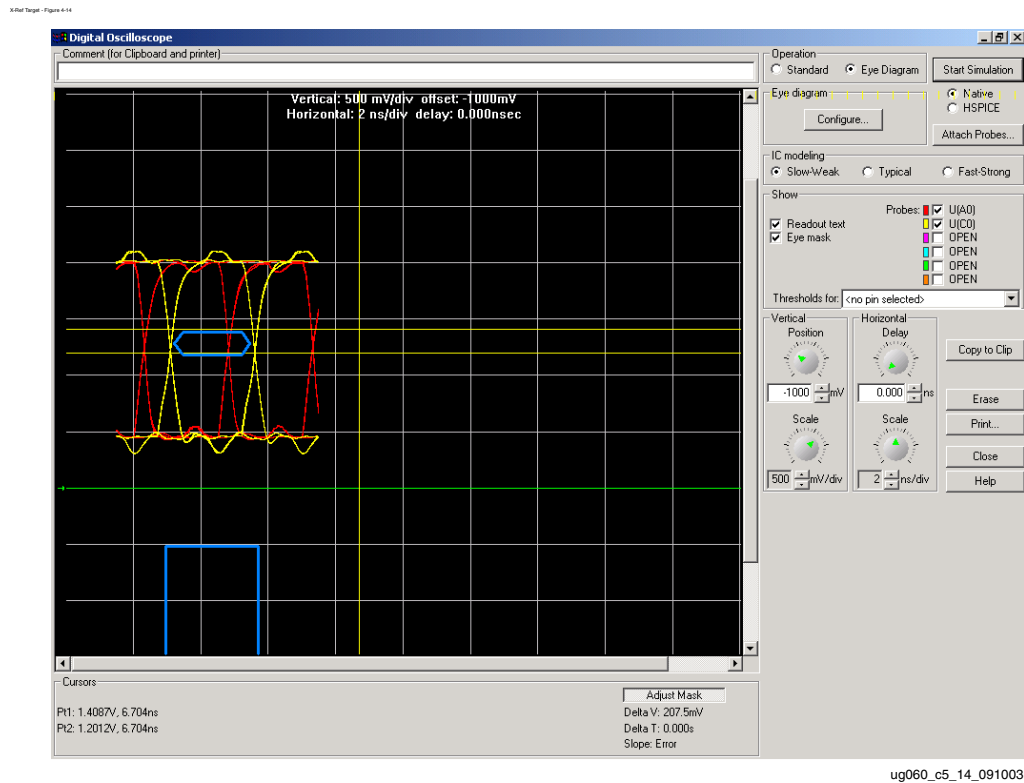


Figure 4-14: Eye Diagram for Clock at Memory

## Address and Control Signal Simulations

The simulations in this subsection test the unidirectional address and control signals from the FPGA to five DDR memory components. Simulations were performed on the first, middle, and last DDR memory component for the following cases: typical, slow weak, and fast strong.

All clock signal simulations below have the following test conditions for typical, slow weak, and fast strong cases:

- Topology: The FPGA and the five DDR components are placed in a straight line in a daisy chain configuration.
  - ◆ The distance between the FPGA and the first DDR component – 2.1 inches
  - ◆ The distance between adjacent DDR components – 0.7 inches
  - ◆ The distance between the FPGA and the last DDR component – 4.8 inches
- At memory (yellow signal): 50Ω resistor pulled up to 1.3 V after the last DDR SDRAM component.
- At FPGA (red signal): 50Ω transmission line is used (SSTL2C2 drivers at the FPGA).

Figure 4-15 shows the address and control signal terminations.

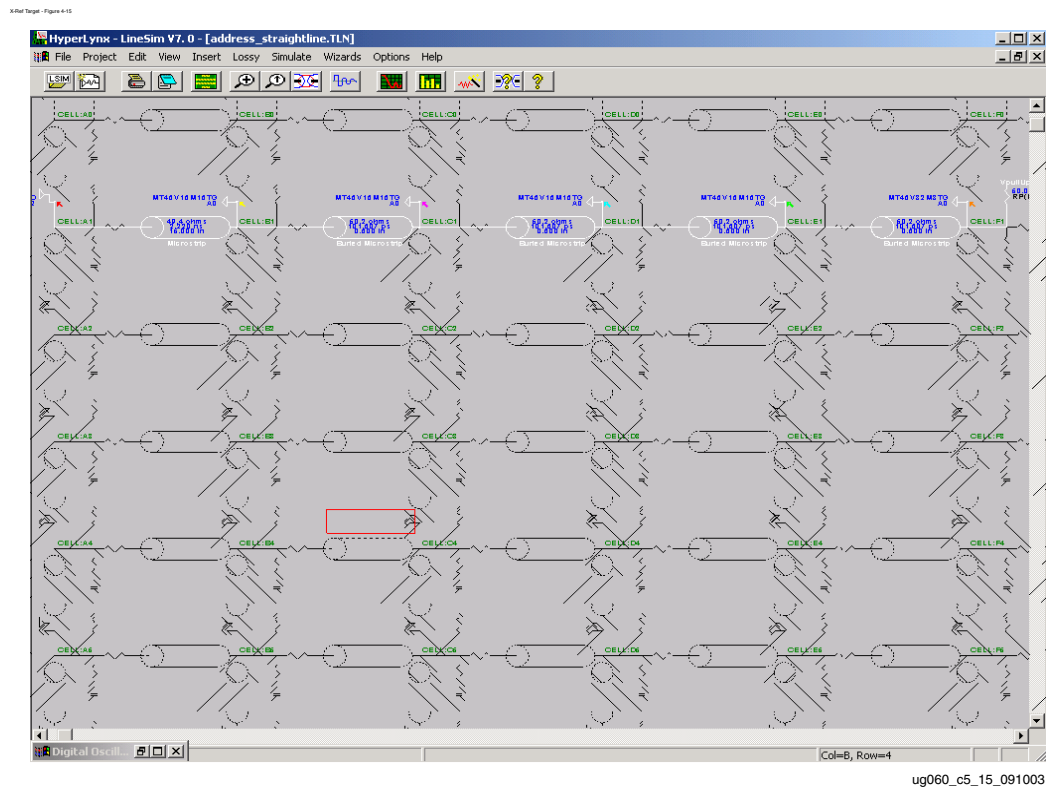


Figure 4-15: Address and Control Signal Terminations

## Typical Case Simulation at All Memory Components

Figure 4-16 shows the simulation screen capture for the typical case for all memory components.

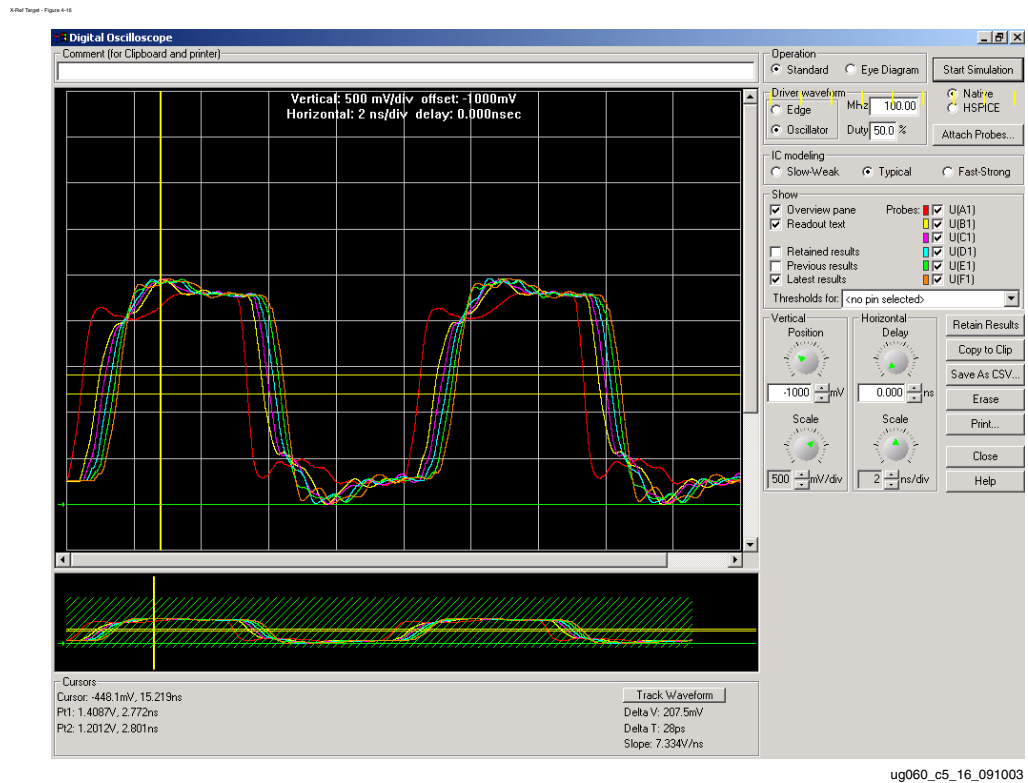
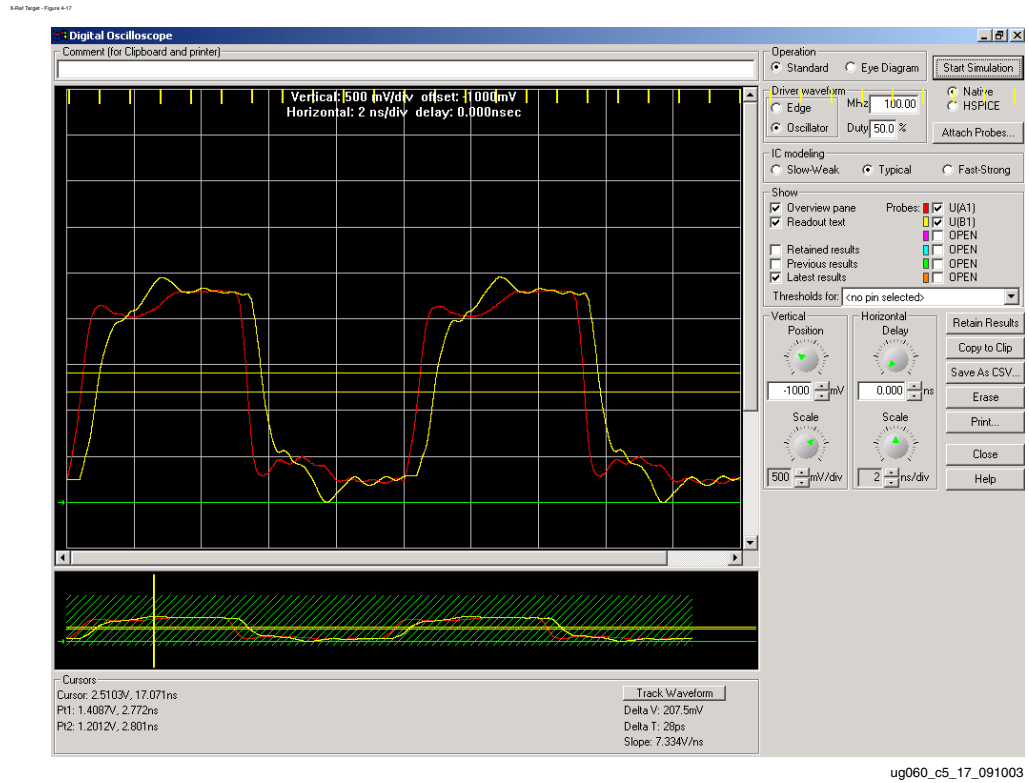


Figure 4-16: Address/Control Signals for All Memories

### Typical Case Simulation at First DDR Component

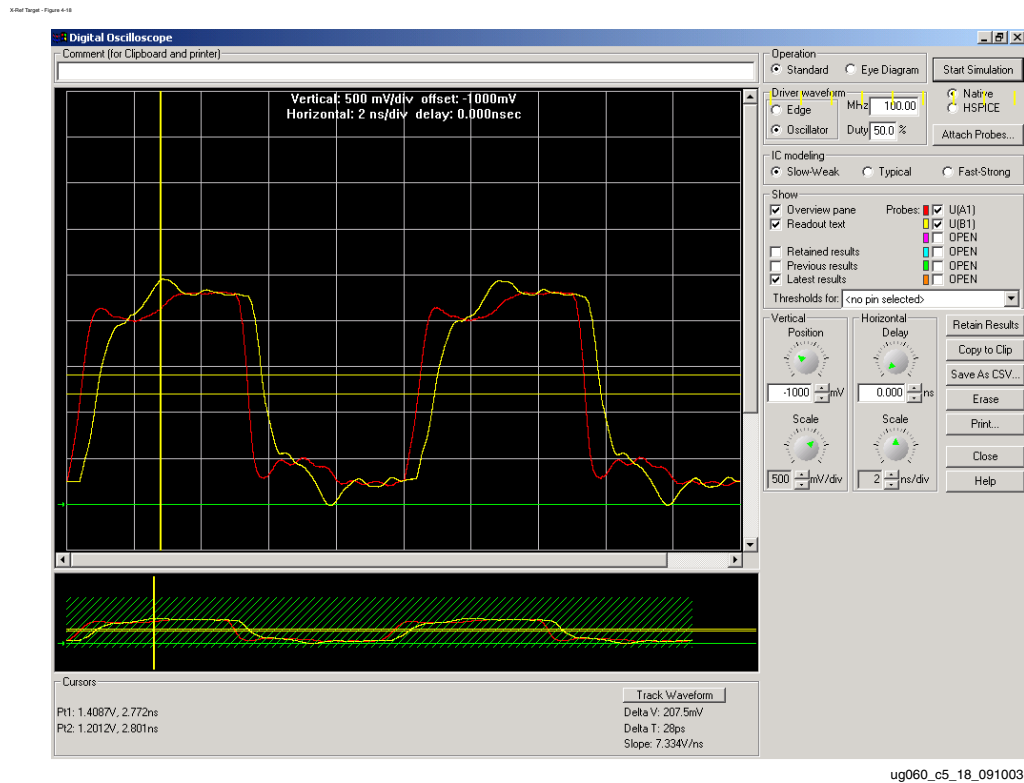
For the typical case simulation at the first DDR component, the resulting duty cycle is 48.94/51.2. [Figure 4-17](#) shows the simulation screen capture for this case.



**Figure 4-17: Address/Control Signals at First DDR Memory (Typical Case)**

### Slow Weak Corner Case Simulation at First DDR Component

For the slow weak corner case simulation at the first DDR component, the resulting duty cycle is 49.22/51.48. [Figure 4-18](#) shows the simulation screen capture for this case.



**Figure 4-18: Address/Control Signals at First DDR Memory (Slow Weak Case)**



### Fast Strong Corner Case Simulation at First DDR Component

For the fast strong corner case simulation at the first DDR component, the resulting duty cycle is 48.66/51.2. Figure 4-19 shows the simulation screen capture for this case.

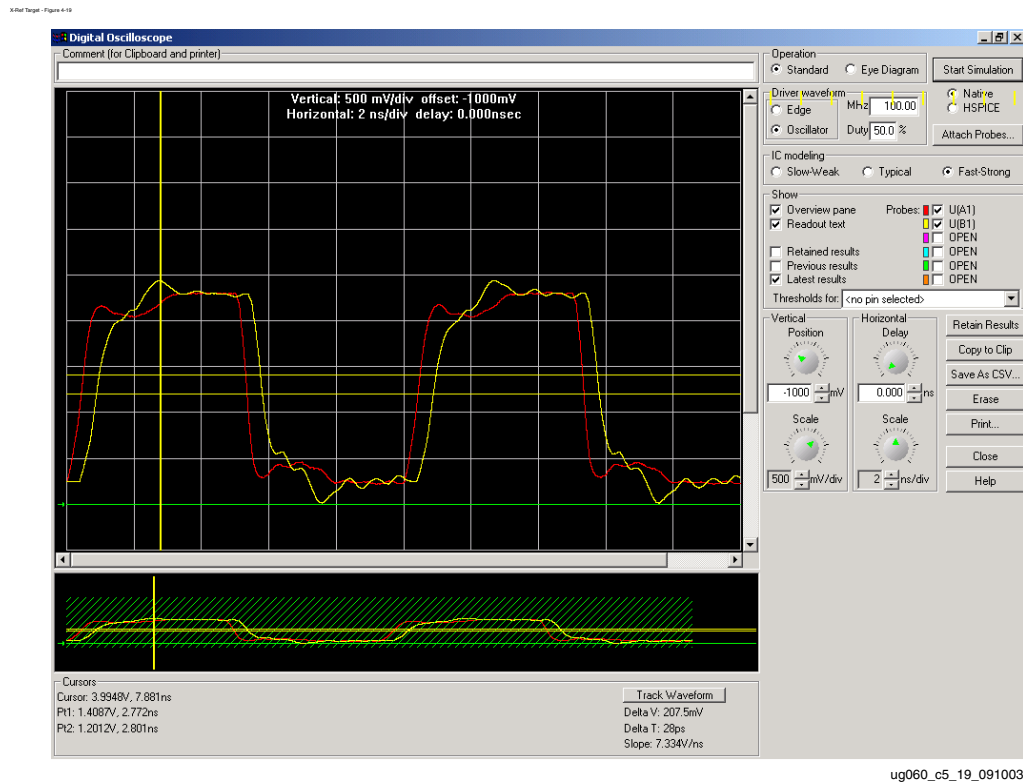
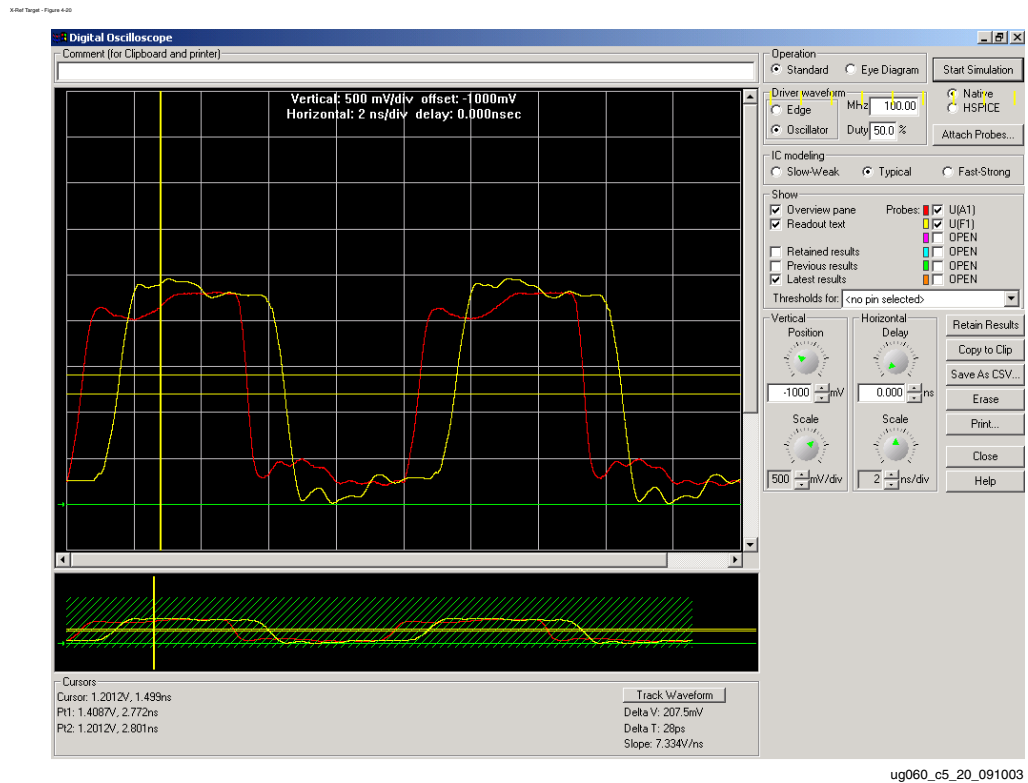


Figure 4-19: Address/Control Signals at First DDR Memory (Fast Strong Case)

### Typical Case Simulation at Last DDR Component

For the typical case simulation at the last DDR component, the resulting duty cycle is 49.22/50.92. [Figure 4-20](#) shows the simulation screen capture for this case.



**Figure 4-20: Address/Control Signals at Last DDR Memory (Typical Case)**

### Slow Weak Case Simulation at Last DDR Component

For the slow weak case simulation at the last DDR component, the resulting duty cycle is 49.22/50.63. Figure 4-21 shows the simulation screen capture for this case.

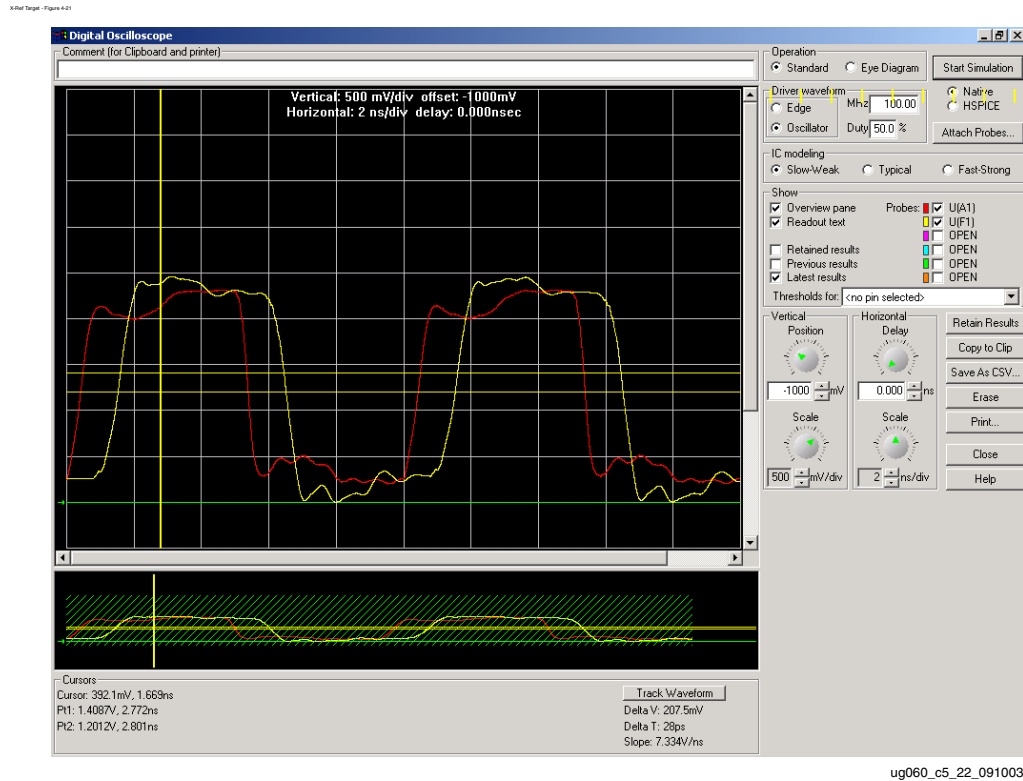
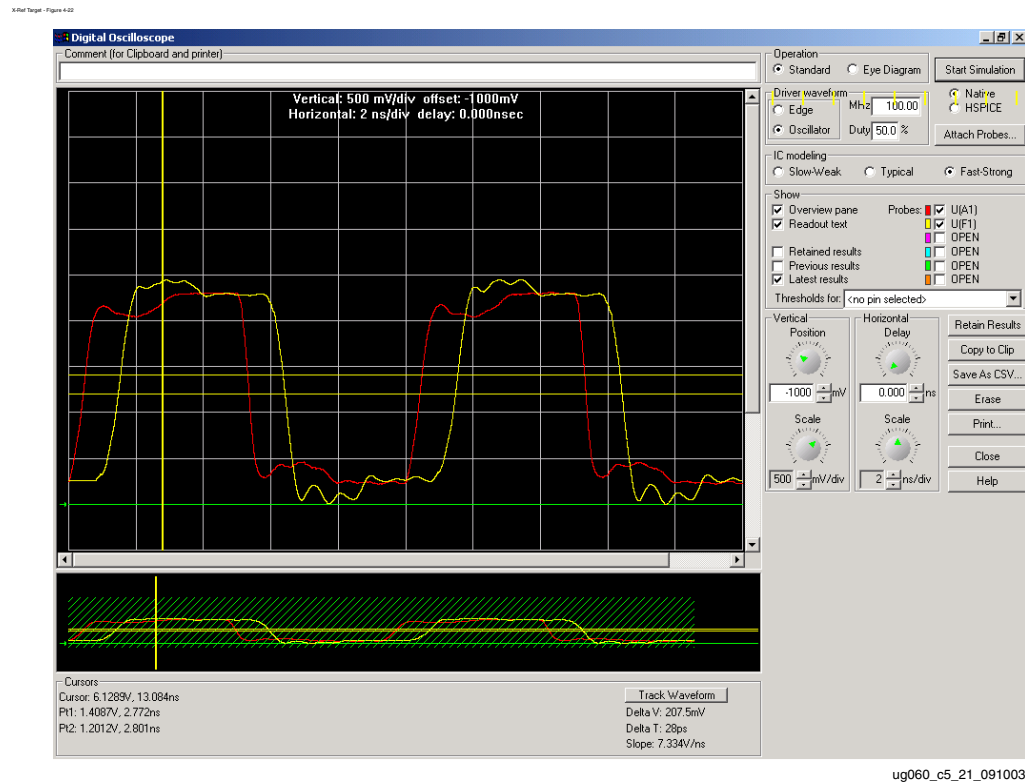


Figure 4-21: Address/Control Signals at Last DDR Memory (Slow Weak Case)

### Fast Strong Corner Case Simulation at Last DDR Component

For the fast strong corner case simulation at the last DDR component, the resulting duty cycle is 49.22/51.2. [Figure 4-22](#) shows the simulation screen capture for this case.



**Figure 4-22: Address/Control Signals at Last DDR Memory (Fast Strong Corner Case)**

### Typical Case Simulation at Middle DDR Component

For the typical case simulation at the middle DDR component, the resulting duty cycle is 49.23/51.49. Figure 4-23 shows the simulation screen capture for this case.

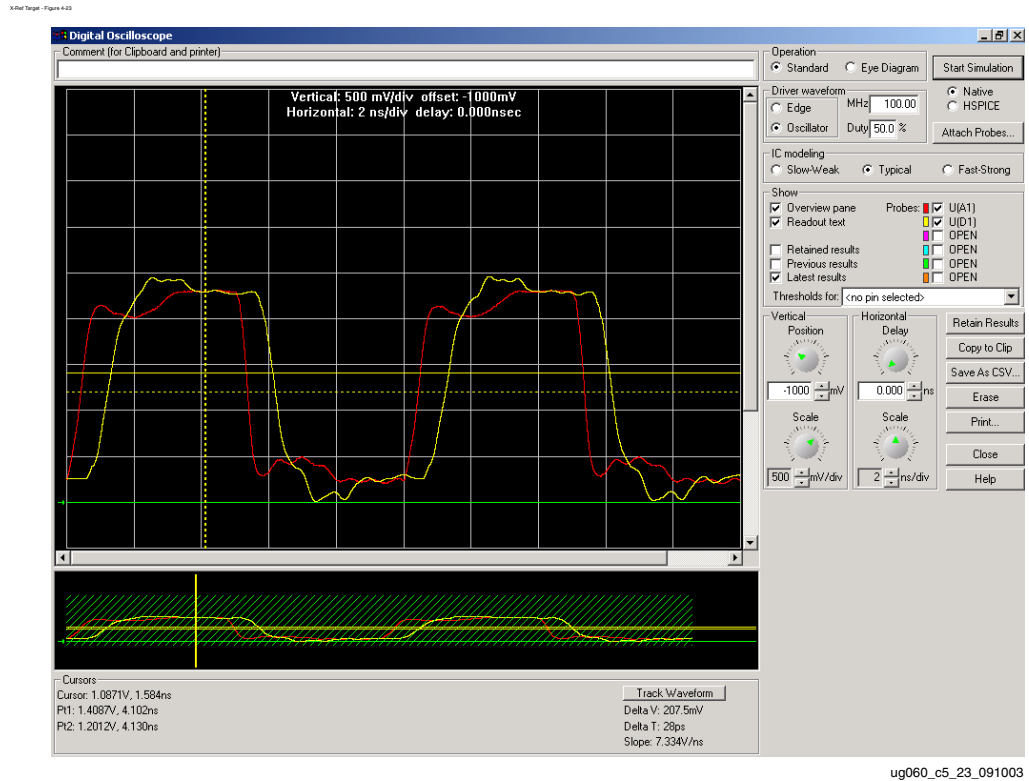
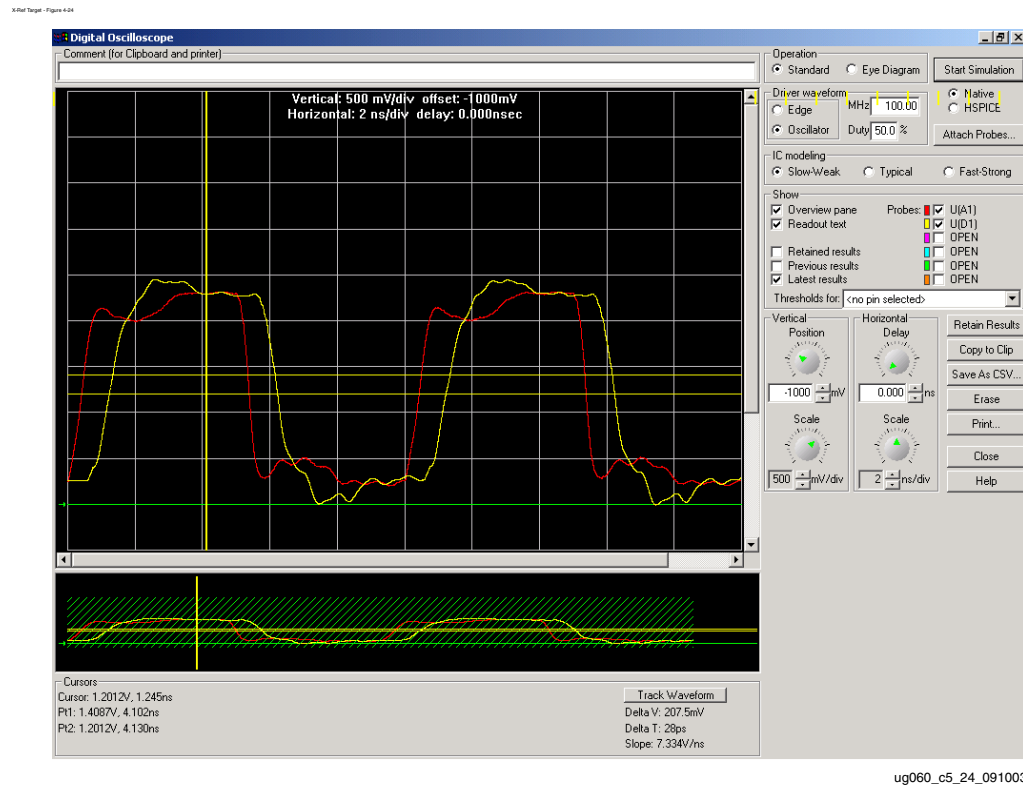


Figure 4-23: Address/Control Signals at Middle DDR Memory (Typical Case)

### Slow Weak Corner Case Simulation at Middle DDR Component

For the slow weak corner case simulation at the middle DDR component, the resulting duty cycle is 49.22/50.64. [Figure 4-24](#) shows the simulation screen capture for this case.



**Figure 4-24: Address/Control Signals at Middle DDR Memory (Slow Weak Corner Case)**

### Fast Strong Corner Case Simulation at Middle DDR Component

For the fast strong corner case simulation at the middle DDR component, the resulting duty cycle is 48.94/51.2. Figure 4-25 shows the simulation screen capture for this case.

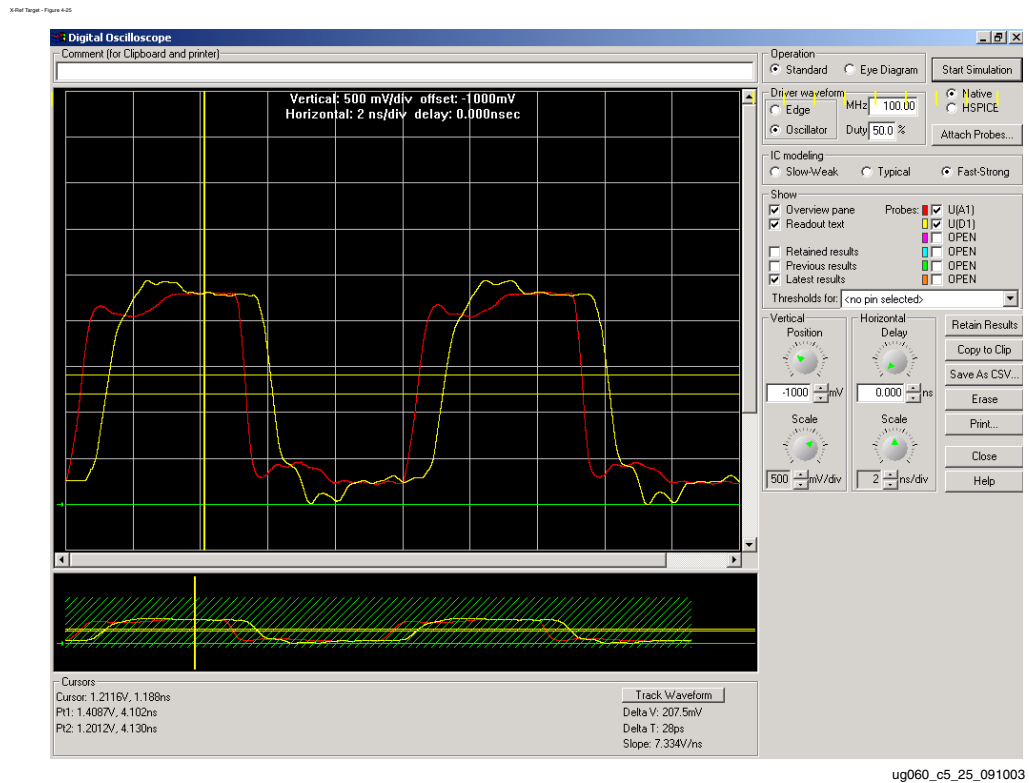


Figure 4-25: Address/Control Signals at Middle DDR Memory (Fast Strong Corner Case)

## Simulations with 10% Tolerance on the Transmission Line Impedance

These simulations illustrate the typical cases for data, clock, and address and control signals.

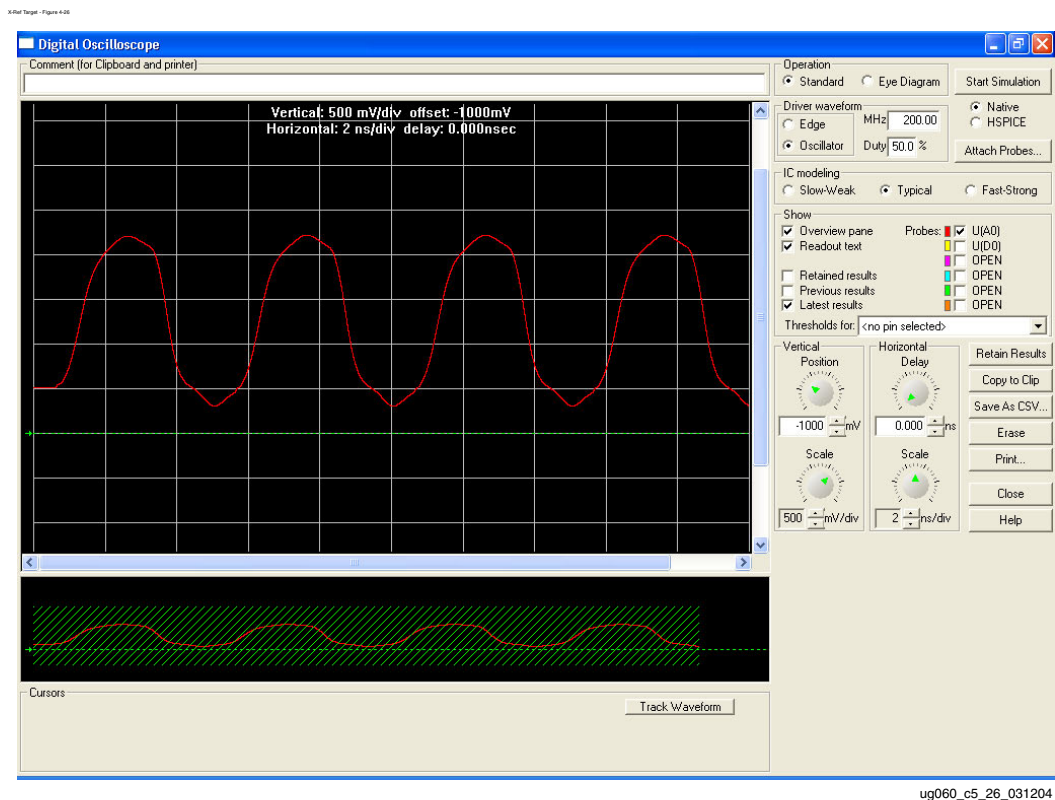
### Data Signals

This subsection provides the data simulation results for the following typical cases:

- From the last DDR memory to the FPGA (45Ω transmission line impedance)
- From the last DDR memory to the FPGA (55Ω transmission line impedance)
- From the FPGA to the last DDR memory (45Ω transmission line impedance)
- From the memory to the FPGA (55Ω transmission line impedance)

### Data Signals from the Last DDR Memory to the FPGA with 45Ω Transmission Line Impedance

For the typical case simulation from the last DDR component to the FPGA, the resulting duty cycle is 48.66/51.48. [Figure 4-26](#) shows the simulation screen capture for this case.

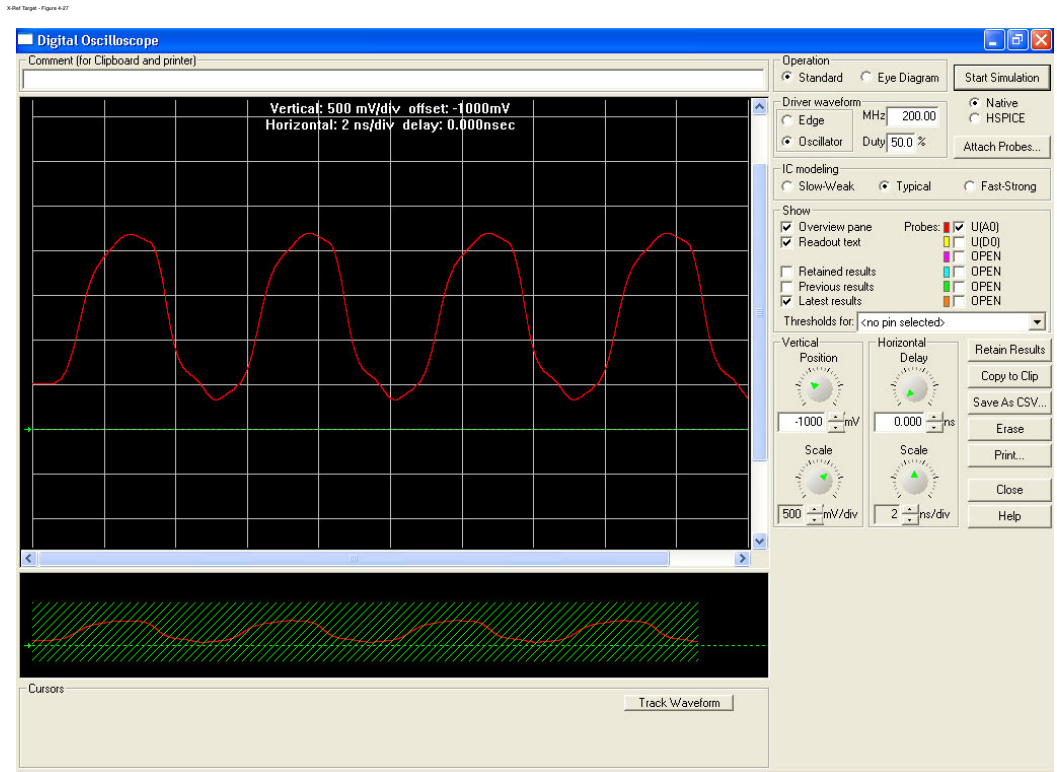


**Figure 4-26: Data Signals from Last DDR Memory to FPGA (45Ω Impedance)**



### Data Signals from the Last DDR Memory to the FPGA with 55Ω Transmission Line Impedance

For the typical case simulation from the last DDR component to the FPGA, the resulting duty cycle is 46.4/52.62. [Figure 4-27](#) shows the simulation screen capture for this case.

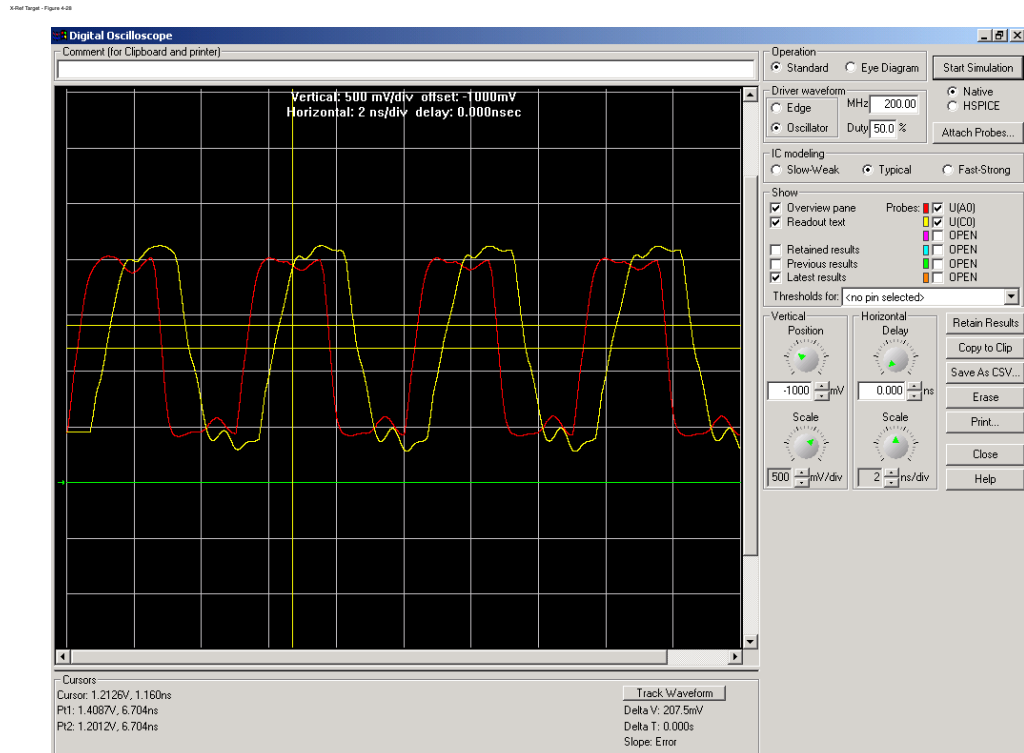


ug060\_c5\_27\_031204

**Figure 4-27: Data Signals from Last DDR Memory to FPGA (55Ω Impedance)**

## Data Signals from FPGA to the Last DDR Memory Component with 45Ω Transmission Line Impedance

For the typical case simulation from the FPGA to the last DDR component, the resulting duty cycle is 46.96/53.18. [Figure 4-28](#) shows the simulation screen capture for this case.



ug060\_c5\_28\_091003

**Figure 4-28: Data Signals from FPGA to Last DDR Memory (45Ω Impedance)**

### Data Signals from Memory to the FPGA with 55Ω Transmission Line Impedance

For the typical case simulation from memory to the FPGA, the resulting duty cycle is 48.66/51.48. [Figure 4-29](#) shows the simulation screen capture for this case.

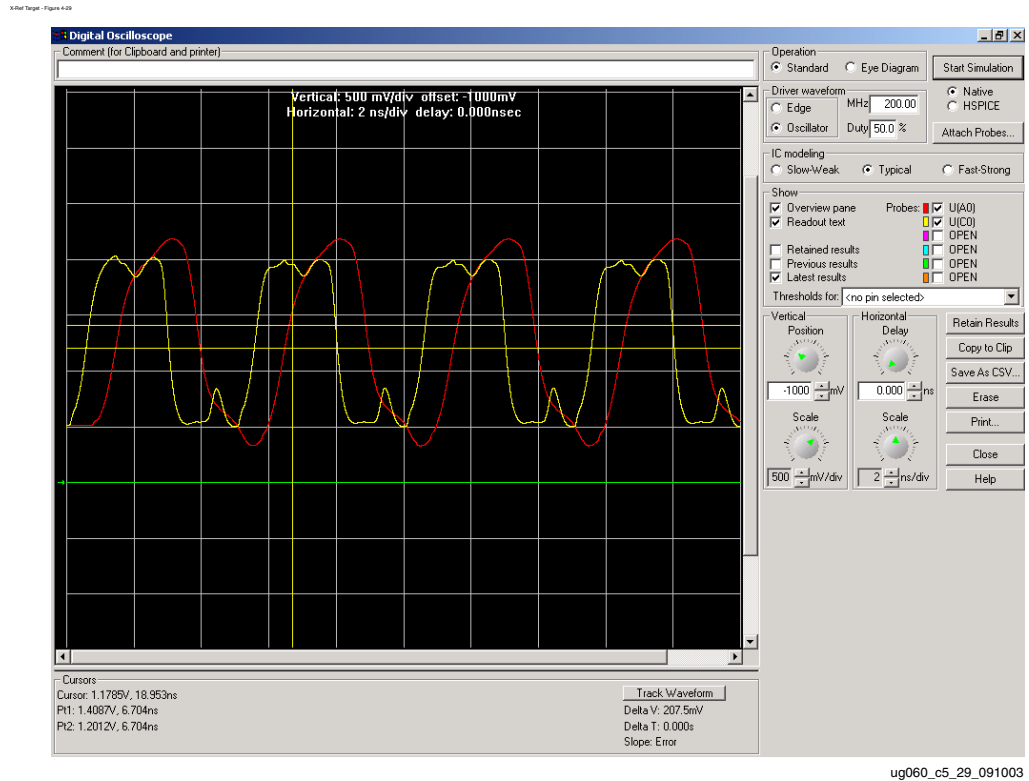


Figure 4-29: Data Signals from Memory to FPGA (55Ω Impedance)

## Clock Signals

This subsection provides the clock simulation results for the following typical cases:

- With 45Ω transmission line impedance
- With 55Ω transmission line impedance

### Clock Signals with 45Ω Transmission Line Impedance

For the typical case simulation with a 45Ω transmission line impedance, the resulting duty cycle is 48.66/ 52.04. [Figure 4-30](#) shows the simulation screen capture for this case.

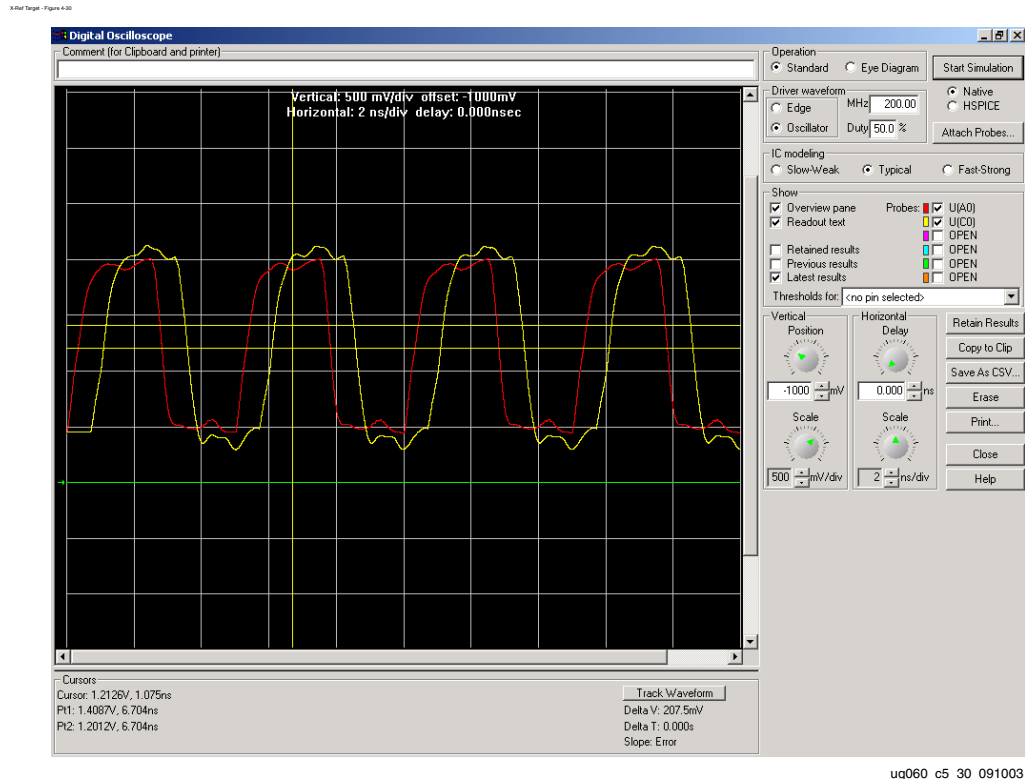
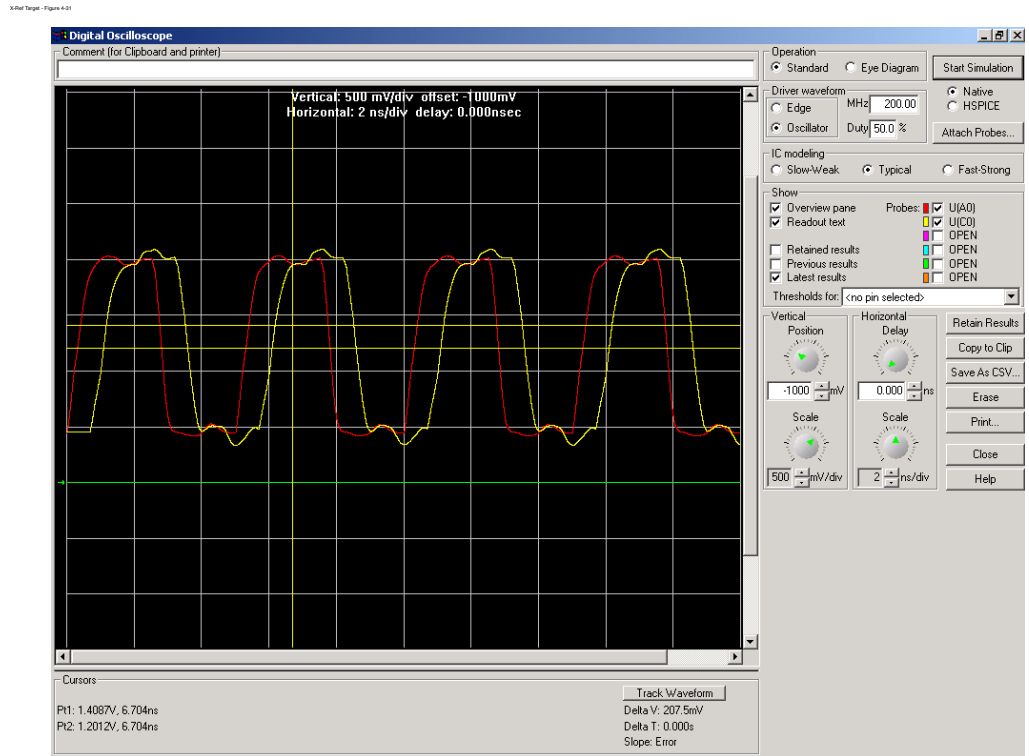


Figure 4-30: Clock Signals with 45Ω Impedance

### Clock Signals with 55Ω Transmission Line Impedance

For the typical case simulation with a 55Ω transmission line impedance, the resulting duty cycle is 48.1/51.48. Figure 4-31 shows the simulation screen capture for this case.



ug060\_c5\_31\_091003

Figure 4-31: Clock Signals with 55Ω Impedance

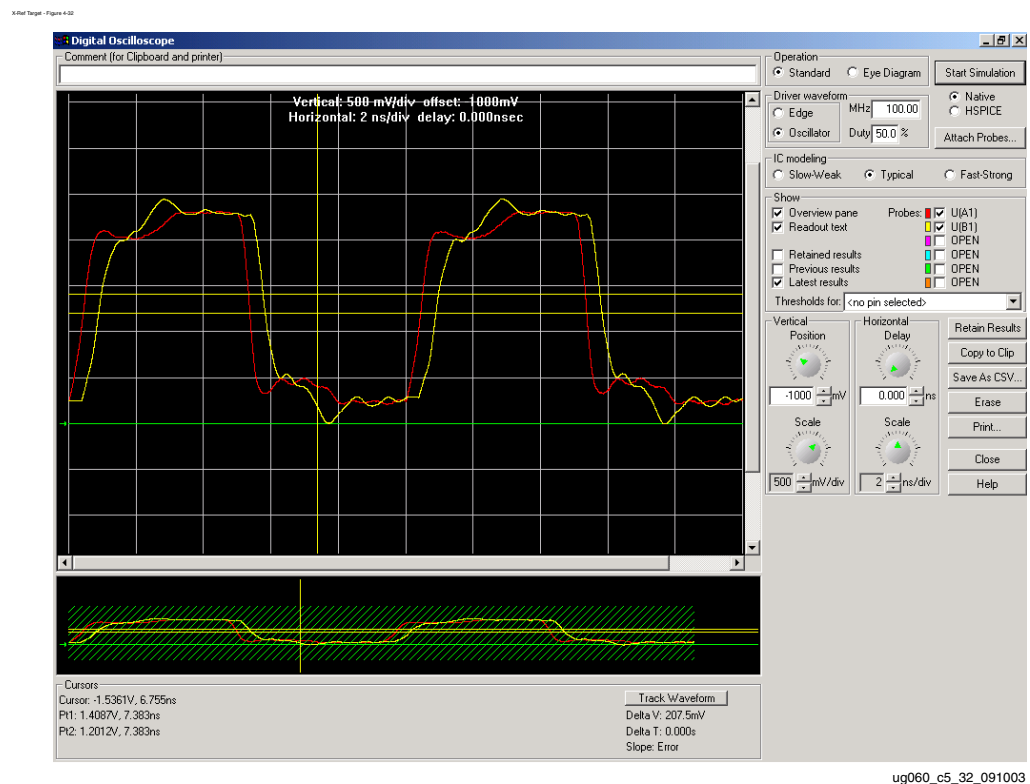
## Address/Control Signals

This subsection provides the address and control simulation results for the following typical cases:

- With  $45\Omega$  transmission line impedance measured at the first DDR component
- With  $55\Omega$  transmission line impedance measured at the first DDR component

### Address and Control Signals with $45\Omega$ Transmission Lines Measured at the First DDR Component

For the typical case simulation with a  $45\Omega$  transmission line impedance measured at the first DDR component, the resulting duty cycle is 48.94/51.2. [Figure 4-32](#) shows the simulation screen capture for this case.



**Figure 4-32: Address/Control Signals with  $45\Omega$  Impedance Measured at First DDR Component**

### Address and Control Signals with 55Ω Transmission Lines Measured at the First DDR Component

For the typical case simulation with a 55Ω transmission line impedance measured at the first DDR component, the resulting duty cycle is 48.66/51.48. Figure 4-33 shows the simulation screen capture for this case.

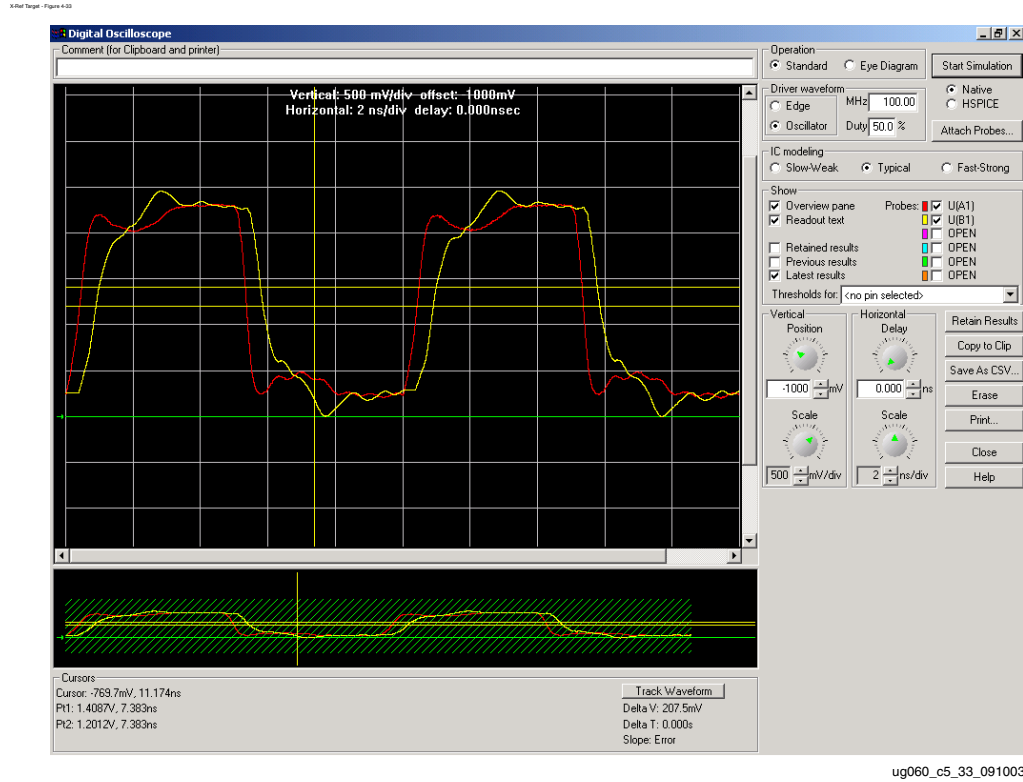


Figure 4-33: Address/Control Signals with 55Ω Impedance Measured at First DDR Component





## Board Layout Guidelines

This chapter provides information on decoupling capacitors, ground signals, and PCB layout.

### Decoupling Guidelines

This section lists the decoupling capacitors used with the major components of the ML361 board. Refer to the board schematics for exact placement.

[Table 5-1](#) lists the decoupling capacitors for the Virtex-II Pro FPGA. Refer to the Xilinx [XAPP623](#) application note for the methodology. A balanced decoupling network is implemented for each bank, VCCI, VAUX, and VREF.

**Table 5-1: FPGA Decoupling Capacitors**

Pin(s)	Capacitor Value	Distribution
VCCI	0.039 $\mu$ F ceramic capacitor, 0402 10V X7R -20/+20%	10
1 capacitor per pin, in a balanced decoupling network.	0.22 $\mu$ F ceramic capacitor, 0603 10V X7R -20/+20%	5
	1 $\mu$ F ceramic capacitor, 0603 6V X7R -20/+20%	6
	10 $\mu$ F ceramic capacitor, 1206 16V Z5U -20/+20%	3
	330 $\mu$ F solid tantalum capacitor, 6.3V	2
	VAUX	0.039 $\mu$ F ceramic capacitor, 0402 10V X7R -20/+20%
1 capacitor per pin, in a balanced decoupling network.	0.22 $\mu$ F ceramic capacitor, 0603 10V X7R -20/+20%	3
	1 $\mu$ F ceramic capacitor, 0603 6V X7R -20/+20%	3
	10 $\mu$ F ceramic capacitor, 1206 16V Z5U -20/+20%	1
	330 $\mu$ F solid tantalum capacitor, 6.3V	1
	Bank 2	Budget = $(61/120) = .51 \times 12 = 7$ caps
39 SSTL2_II 20 SSTL2_I	0.039 $\mu$ F ceramic capacitor, 0402 10V X7R -20/+20%	2
	0.22 $\mu$ F ceramic capacitor, 0603 10V X7R -20/+20%	1
	1 $\mu$ F ceramic capacitor, 0603 6V X7R -20/+20%	1
	330 $\mu$ F solid tantalum capacitor, 6.3V	1

Table 5-1: FPGA Decoupling Capacitors (Cont'd)

Pin(s)	Capacitor Value	Distribution
Bank 2 VREF	7 VREFs used, one capacitor for each VREF	
	0.039 $\mu$ F ceramic capacitor, 0402 10V X7R -20/+20%	2
	0.22 $\mu$ F ceramic capacitor, 0603 10V X7R -20/+20%	1
	1 $\mu$ F ceramic capacitor, 0603 6V X7R -20/+20%	1
	330 $\mu$ F solid tantalum capacitor, 6.3V	1, shared with bank 3
Bank 3	Same as Bank 2 for both I/Os and VREFs	
Bank 6	Same as Bank 2 for both I/Os and VREFs	
Bank 7	Same as Bank 2 for both I/Os and VREFs	
Bank 1 1 Reset, 8 GPIO, 4 LED, 8 DIP, 14 DISPLAY	0.033 $\mu$ F ceramic capacitor, 0402 6V X7R -20/+20%	1
	0.22 $\mu$ F ceramic capacitor, 0603 6V X7R -20/+20%	1
	1 $\mu$ F ceramic capacitor, 0603 6V X7R -20/+20%	1
	330 $\mu$ F solid tantalum capacitor, 6.3V	1
Bank 0	Similar to Bank 1	
Bank 4	Similar to Bank 1	
Bank 5	Similar to Bank 1	

Table 5-2 lists the decoupling capacitors for the DDR SDRAMs.

Table 5-2: DDR SDRAM Decoupling Capacitors

Pin(s)	Capacitor Value	Quantity	Distribution
VDD, VDDQ, VREF, VSS, VSSQ	0.01 $\mu$ F ceramic capacitor, 0402 6V X7R -20/+20%	8	1 capacitor per pin, in a balanced decoupling network. 17 total for each component
	0.1 $\mu$ F ceramic capacitor, 0603 6V X7R -20/+20%	8	
	330 $\mu$ F solid tantalum capacitor, 6.3V	1	

Table 5-3 lists the decoupling capacitors for the DDR DIMM.

Table 5-3: DIMM Decoupling Capacitors

Pin(s)	Capacitor Value	Distribution
VDD	0.01 $\mu$ F ceramic capacitor, 0402 6V X7R -20/+20%	1 per VDD pin
	0.1 $\mu$ F ceramic capacitor, 0603 6V X7R -20/+20%	1 per VDD pin
	330 $\mu$ F solid tantalum capacitor, 6.3V	1
VDDQ	0.01 $\mu$ F ceramic capacitor, 0402 6V X7R -20/+20%	1 per VDDQ pin
	0.1 $\mu$ F ceramic capacitor, 0603 6V X7R -20/+20%	1 per VDDQ pin
	330 $\mu$ F solid tantalum capacitor, 6.3V	2

Table 5-3: DIMM Decoupling Capacitors (Cont'd)

Pin(s)	Capacitor Value	Distribution
VREF	0.01 $\mu$ F ceramic capacitor, 0402 6V X7R -20/+20%	1 VREF to GND 1 VREF to 2.6V 1 GND to 2.6V
	0.1 $\mu$ F ceramic capacitor, 0603 6V X7R -20/+20%	1 VREF to GND 1 VREF to 2.6V 1 GND to 2.6V
VSS	0.01 $\mu$ F ceramic capacitor, 0402 6V X7R -20/+20%	8
	0.1 $\mu$ F ceramic capacitor, 0603 6V X7R -20/+20%	4
	330 $\mu$ F solid tantalum capacitor, 6.3V	1

## Providing Additional Ground Pins

Additional Ground pins can be added by tying unused and no connect pins to GND.

## Board Stackup Guidelines

Table 5-4 shows a suggested stackup of a 16-layer board (8 signals, 8 planes).

Table 5-4: 16-Layer Board Stackup

#	Type	Layer	Trace / Spacing	Comments
1	Signal	TOP	8 mil, 8 mil	
2	Plane	GND		GND
3	Plane	+2.5V		+2.5V separate plane
4	Signal-X	IN1	5 mil, 5 mil	Route clocks on IN1 and IN2 layers. Can be used for carefully routing SSTL signals, if routing area needed
5	Signal-Y	IN2	5 mil, 5 mil	
6	Plane	+2.6V		
7	Plane	GND		
8	Signal-X	IN3	5 mil, 5 mil	Route all 200 MHz SSTL signals on IN3 and IN4
9	Signal-Y	IN4	5 mil, 5 mil	
10	Plane	GND		
11	Plane	+1.3V & +1.5V		Carve out two power planes on this layer
12	Signal-X	IN5	5 mil, 5 mil	Route other non-critical signals here
13	Signal-Y	IN6	5 mil, 5 mil	
14	Plane	+3.3V		
15	Plane			GND
16	Signal	BOT	8 mil, 8 mil	In the area not used for routing on this layer, add GND fill to give +3.3V planar capacitance.



## Related Documentation

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This appendix provides references to documents and web pages for components on the ML361 board.

- Xilinx, Inc.
  - ◆ Virtex-II Pro X™ Platform FPGAs  
<http://www.xilinx.com/bvdocs/publications/ds083.pdf>
  - ◆ Platform Flash In-System Programmable Configuration PROMs  
<http://www.xilinx.com/bvdocs/publications/ds123.pdf>
- Texas Instruments
  - ◆ PTH05000BAH Regulated Step-down DC/DC 5V to 3.3V @ 5.5A  
PTH05000FAH Regulated Step-down DC/DC 5V to 1.5V @ 5.5A  
<http://focus.ti.com/lit/ds/symlink/pth05000w.pdf>
  - ◆ PTH05010WAS Regulated Step-down DC/DC 5V to 2.5V @ 10A  
<http://focus.ti.com/lit/ds/symlink/pth05010w.pdf>
  - ◆ MAX3221CDBR RS232 Interface  
<http://focus.ti.com/lit/ds/symlink/max3221.pdf>
- Micron
  - ◆ Micron DDR SDRAM Components  
<http://download.micron.com/pdf/datasheets/dram/ddr/256Mx4x8x16DDR.pdf>
  - ◆ Micron DDR SDRAM DIMM  
[http://download.micron.com/pdf/datasheets/modules/ddr/DDA4C16\\_32x64AG.pdf](http://download.micron.com/pdf/datasheets/modules/ddr/DDA4C16_32x64AG.pdf)
- Pletronics, Inc.
  - ◆ LV1145BV-166.0M-REX 3.3V High Frequency LVDS Oscillator 166 MHz  
LV1145BV-200.0M-REX 3.3V High Frequency LVDS Oscillator 200 MHz  
<http://www.pletronics.com/LV1100B.HTM>
- Agilent Technologies
  - ◆ Logic Analyzer: *Agilent Technologies 16753/54/55/56 Logic Analyzer*  
<http://cp.literature.agilent.com/litweb/pdf/5988-9043EN.pdf>
  - ◆ Logic Analyzer Probes: *Agilent Technologies Connector-based Probes*  
<http://cp.literature.agilent.com/litweb/pdf/16760-97012.pdf>



## FPGA Pinout

Table B-1 summarizes the pinout of the XC2VP20FF1152-6 FPGA in the ML361 board. The slice coordinates mentioned in Table B-1 refer to the RPM grid coordinates corresponding to the respective I/O pin location. I/O pin names marked as *GND* refer to unused I/Os that are directly connected to GND. I/O pin names marked as *PULLDOWN* refer to unused I/Os that are connected to GND through a zero ohm resistor. The 0Ω resistor can be removed to use the corresponding I/O for any test purposes.

Table B-1: FPGA Pinout

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
U23	7	VCCO_7			
E29	0	IO_L01N_0/VRP_0	RXD		11097.26
E28	0	IO_L01P_0/VRN_0	TXD		10150.32
H26	0	IO_L02N_0	resetN		6327.18
G26	0	IO_L02P_0	DIP1		7905.95
H25	0	IO_L03N_0	DIP2		5691.71
G25	0	IO_L03P_0/VREF_0	DIP3		6996.94
J25	0	IO	DIP4		5273.75
K24	0	IO_L06N_0	DIP5		3344.34
J24	0	IO_L06P_0	DIP6		4601.94
F26	0	IO_L07N_0	DIP7		9207.2
E26	0	IO_L07P_0	DIP8		10718.03
D30	0	IO_L08N_0	GPIO08		15834.96
D29	0	IO_L08P_0	GPIO09		14848.81
K23	0	IO_L09N_0	GPIO10		3066.04
J23	0	IO_L09P_0/VREF_0	GPIO11		4323.64
H22	0	IO_L37N_0	GPIO12		4727.82
G22	0	IO_L37P_0	GPIO13		5923
D26	0	IO_L38N_0	GPIO14		15218.77
C26	0	IO_L38P_0	GPIO15		15469.57

**Table B-1: FPGA Pinout (Cont'd)**

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
K21	0	IO_L39N_0	GND		5505.04
J21	0	IO_L39P_0	GND		4965.14
F22	0	IO_L43N_0	GPIO00		7541.44
E22	0	IO_L43P_0	GPIO01		8910.89
E25	0	IO_L44N_0	GPIO02		12735.3
D25	0	IO_L44P_0	GPIO03		13832.18
H21	0	IO_L45N_0	GPIO04		6364.26
G21	0	IO_L45P_0/VREF_0	GPIO05		7704.24
D22	0	IO_L46N_0	GPIO06		9988.1
D23	0	IO_L46P_0	GPIO07		11050.72
D24	0	IO_L47N_0	DISPLAY1G		12302.96
C24	0	IO_L47P_0	DISPLAY1F		13516.13
K20	0	IO_L48N_0	DISPLAY1E		3126.3
J20	0	IO_L48P_0	DISPLAY1D		4150.17
F21	0	IO_L49N_0	DISPLAY1C		7682.05
E21	0	IO_L49P_0	DISPLAY1B		8634.04
C21	0	IO	DISPLAY1A		13499.9
C22	0	IO	DISPLAY2G		15061.08
L19	0	IO_L54N_0	DISPLAY2F		2263.39
K19	0	IO_L54P_0	DISPLAY2E		3226.4
G20	0	IO_L55N_0	DISPLAY2D		6227.05
F20	0	IO_L55P_0	DISPLAY2C		7549.54
D21	0	IO_L56N_0	DISPLAY2B		10983.43
D20	0	IO_L56P_0	DISPLAY2A		10275.3
J19	0	IO_L57N_0	GND		3969.14
H19	0	IO_L57P_0/VREF_0	GND		5173.85
G19	0	IO_L67N_0	GND		6064.32
F19	0	IO_L67P_0	GND		8063.93
E19	0	IO_L68N_0	GND		9549.27
D19	0	IO_L68P_0	GND		10957.97
L18	0	IO_L69N_0	LED1		2444
K18	0	IO_L69P_0/VREF_0	LED2		3320.11
G18	0	IO_L73N_0	LED3		5890.16



**Table B-1: FPGA Pinout (Cont'd)**

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
F18	0	IO_L73P_0	LED4		7223.69
E18	0	IO_L74N_0/GCLK7P	GND		8692.96
D18	0	IO_L74P_0/GCLK6S	GND		9819.09
J18	0	IO_L75N_0/GCLK5P	GND		3858.95
H18	0	IO_L75P_0/GCLK4S	GND		5131.43
H17	1	IO_L75N_1/GCLK3P	CLK_200_LVDSN		5131.43
J17	1	IO_L75P_1/GCLK2S	CLK_200_LVDSP		3858.95
D17	1	IO_L74N_1/GCLK1P	CLK_166_LDVSN		10242.07
E17	1	IO_L74P_1/GCLK0S	CLK_166_LVDSP		8752.34
F17	1	IO_L73N_1	top_clkb		7223.69
G17	1	IO_L73P_1	top_clk		5890.16
K17	1	IO_L69N_1/VREF_1	Vref = 1.3V		3320.11
L17	1	IO_L69P_1	top_dqs		2444
D16	1	IO_L68N_1	top_dq(0)		10931.46
E16	1	IO_L68P_1	top_dq(1)		9549.27
F16	1	IO_L67N_1	top_dq(2)		8063.93
G16	1	IO_L67P_1	top_dq(3)		6064.32
H16	1	IO_L57N_1/VREF_1	Vref = 1.3V		5173.85
J16	1	IO_L57P_1	top_dq(4)		3969.14
D15	1	IO_L56N_1	top_dq(5)		10275.3
D14	1	IO_L56P_1	top_dq(6)		10983.43
F15	1	IO_L55N_1	top_dq(7)		7549.54
G15	1	IO_L55P_1	top_dm		6227.05
K16	1	IO_L54N_1	top_cke		3226.4
L16	1	IO_L54P_1	top_address(0)		2263.39
C13	1	IO	top_address(1)		15102.5
C14	1	IO	top_address(2)		13541.32
E14	1	IO_L49N_1	top_address(3)		8634.04
F14	1	IO_L49P_1	top_address(4)		7682.05
J15	1	IO_L48N_1	top_address(5)		4150.17
K15	1	IO_L48P_1	top_address(6)		3084.88
C11	1	IO_L47N_1	top_address(7)		13513.12
D11	1	IO_L47P_1	top_address(8)		12295.94

**Table B-1: FPGA Pinout (Cont'd)**

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
D12	1	IO_L46N_1	top_address(9)		11050.72
D13	1	IO_L46P_1	top_address(10)		9988.1
G14	1	IO_L45N_1/VREF_1	Vref = 1.3V		7704.24
H14	1	IO_L45P_1	top_address(11)		6364.26
D10	1	IO_L44N_1	top_address(12)		13570.63
E10	1	IO_L44P_1	top_ba(0)		12296.5
E13	1	IO_L43N_1	top_ba(1)		8910.89
F13	1	IO_L43P_1	top_csb		7591.45
J14	1	IO_L39N_1	GND		4903.25
K14	1	IO_L39P_1	GND		5404.41
C9	1	IO_L38N_1	top_rasb		15339.71
D9	1	IO_L38P_1	top_casb		14631.43
G13	1	IO_L37N_1	top_web		5923
H13	1	IO_L37P_1	GND		4727.82
J12	1	IO_L09N_1/VREF_1	Vref = 1.3V		4323.64
K12	1	IO_L09P_1	top_rst_dqs_div_out		3066.04
D6	1	IO_L08N_1	top_rst_dqs_div_in		15105.89
D5	1	IO_L08P_1	GND		16085.61
E9	1	IO_L07N_1	PULLDOWN		10718.03
F9	1	IO_L07P_1	PULLDOWN		9223.77
J11	1	IO_L06N_1	PULLDOWN		4601.94
K11	1	IO_L06P_1	PULLDOWN		3344.34
J10	1	IO	PULLDOWN		5273.75
G10	1	IO_L03N_1/VREF_1	Vref = 1.3V		6996.94
H10	1	IO_L03P_1	PULLDOWN		5691.71
G9	1	IO_L02N_1	PULLDOWN		7905.95
H9	1	IO_L02P_1	PULLDOWN		6327.18
E7	1	IO_L01N_1/VRP_1	Pulldown to GND for DCI		10150.32
E6	1	IO_L01P_1/VRN_1	Pullup to 2.6V for DCI		11097.26
D2	2	IO_L01N_2/VRP_2	Pulldown to GND for DCI		7113.13
D1	2	IO_L01P_2/VRN_2	Pullup to 2.6V for DCI		4624.16
F8	2	IO_L02N_2	ddr1_ckn0		3390.64
F7	2	IO_L02P_2	ddr1_ck0		5566.52

Table B-1: FPGA Pinout (Cont'd)

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
E4	2	IO_L03N_2	ddr1_ckn1		6738.57
E3	2	IO_L03P_2	ddr1_ck1		14050.12
E2	2	IO_L04N_2/VREF_2	Vref = 1.3V		15547.77
E1	2	IO_L04P_2	ddr1_dqs0		15132.61
J8	2	IO_L05N_2	ddr1_dm3		6469.14
J7	2	IO_L05P_2	ddr1_dm4		7292.33
F5	2	IO_L06N_2	ddr1_dq0		10666.81
F4	2	IO_L06P_2	ddr1_dq1		11858.77
H2	2	IO_L31N_2	ddr1_dq2		12137.04
H1	2	IO_L31P_2	ddr1_dq3		13451.41
M10	2	IO_L32N_2	ddr1_dq4		3062.48
M9	2	IO_L32P_2	ddr1_dq5		4123.3
K5	2	IO_L33N_2	ddr1_dq6		8267.43
K4	2	IO_L33P_2	ddr1_dq7		9537.04
J2	2	IO_L34N_2/VREF_2	Vref = 1.3V	no pin0	12149.07
K2	2	IO_L34P_2	ddr1_dm0		11352.59
L8	2	IO_L35N_2	ddr1_dm1		5592.79
L7	2	IO_L35P_2	ddr1_dm2		6793.53
L6	2	IO_L36N_2	ddr1_rst_dqs_div_in		7367.37
L5	2	IO_L36P_2	ddr1_rst_dqs_div_out		8143.52
K1	2	IO_L37N_2	PULLDOWN		12423.45
L1	2	IO_L37P_2	ddr1_dqs1		12451.17
N10	2	IO_L38N_2	PULLDOWN		2788.42
N9	2	IO_L38P_2	PULLDOWN		3972.59
M7	2	IO_L39N_2	ddr1_dq8		5610.09
M6	2	IO_L39P_2	ddr1_dq9		6975.04
L2	2	IO_L40N_2/VREF_2	Vref = 1.3V		11195.56
M2	2	IO_L40P_2	ddr1_dq10		12186.54
N8	2	IO_L41N_2	ddr1_dq11		4920.17
N7	2	IO_L41P_2	ddr1_dq12		6104.35
L4	2	IO_L42N_2	ddr1_dq13		9001.57
L3	2	IO_L42P_2	ddr1_dq14		10259.17
M4	2	IO_L43N_2	ddr1_dq15		8536.05

**Table B-1: FPGA Pinout (Cont'd)**

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
M3	2	IO_L43P_2	PULLDOWN		9772.91
P10	2	IO_L44N_2	PULLDOWN		2638.82
P9	2	IO_L44P_2	PULLDOWN		3823
N6	2	IO_L45N_2	ddr1_ckn2	no_pin1	6306.01
N5	2	IO_L45P_2	ddr1_ck2		7563.61
M1	2	IO_L46N_2/VREF_2	Vref = 1.3V		11667.8
N1	2	IO_L46P_2	ddr1_dqs2		11804.99
P8	2	IO_L47N_2	GND		4770.58
P7	2	IO_L47P_2	GND		5954.75
N4	2	IO_L48N_2	ddr1_dq16		8437.77
N3	2	IO_L48P_2	ddr1_dq17		9778.21
N2	2	IO_L49N_2	ddr1_dq18		10426.76
P2	2	IO_L49P_2	ddr1_dq19		10530.82
R10	2	IO_L50N_2	ddr1_dq20		2488.12
R9	2	IO_L50P_2	ddr1_dq21		3672.29
P6	2	IO_L51N_2	ddr1_dq22		6499.99
P5	2	IO_L51P_2	ddr1_dq23		7603.44
P4	2	IO_L52N_2/VREF_2	Vref = 1.3V	no_pin2	8102.88
P3	2	IO_L52P_2	ddr1_rasn		9339.48
T11	2	IO_L53N_2	ddr1_casn		1247.81
U11	2	IO_L53P_2	ddr1_wen		1919.47
R7	2	IO_L54N_2	ddr1_cke		4872.84
R6	2	IO_L54P_2	ddr1_csn		6425.42
P1	2	IO_L55N_2	GND		11291.77
R1	2	IO_L55P_2	ddr1_dqs3		11455.67
T10	2	IO_L56N_2	PULLDOWN		2752.93
T9	2	IO_L56P_2	PULLDOWN		3871.63
R4	2	IO_L57N_2	ddr1_dq24		8013.89
R3	2	IO_L57P_2	ddr1_dq25		9271.49
R2	2	IO_L58N_2/VREF_2	Vref = 1.3V		9961.47
T2	2	IO_L58P_2	ddr1_dq26		10173.21
T8	2	IO_L59N_2	ddr1_dq27		4753.73
T7	2	IO_L59P_2	ddr1_dq28		5872.43

Table B-1: FPGA Pinout (Cont'd)

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
T6	2	IO_L60N_2	ddr1_dq29		6031.43
T5	2	IO_L60P_2	ddr1_dq30		7055.3
T4	2	IO_L85N_2	ddr1_dq31		7724.5
T3	2	IO_L85P_2	GND		9056.44
U10	2	IO_L86N_2	ddr1_ba0		2340.31
U9	2	IO_L86P_2	ddr1_ba1		3459.01
U6	2	IO_L87N_2	ddr1_a0	no_pin3	5801.93
U5	2	IO_L87P_2	ddr1_a1		6851.4
U2	2	IO_L88N_2/VREF_2	Vref = 1.3V		9665.64
V2	2	IO_L88P_2	ddr1_dqs4		10394.2
U8	2	IO_L89N_2	GND		4393.22
U7	2	IO_L89P_2	GND		5511.92
U4	2	IO_L90N_2	ddr1_dq32		7649.57
U3	2	IO_L90P_2	ddr1_dq33		8839.91
V3	3	IO_L90N_3	ddr1_dq34		8537.7
V4	3	IO_L90P_3	ddr1_dq35		7799.59
V7	3	IO_L89N_3	ddr1_dq36		5407.06
V8	3	IO_L89P_3	ddr1_dq37		4483.54
V5	3	IO_L88N_3	ddr1_dq38		6547.9
V6	3	IO_L88P_3	ddr1_dq39		5998.02
W2	3	IO_L87N_3/VREF_3	Vref = 1.3V	no_pin4	9812.03
Y2	3	IO_L87P_3	ddr1_a2		10611.96
V9	3	IO_L86N_3	GND		3327.27
V10	3	IO_L86P_3	ddr1_dqs5		2405.17
W3	3	IO_L85N_3	GND		8919.9
W4	3	IO_L85P_3	GND		8159.47
Y1	3	IO_L60N_3	ddr1_dq40		11148.48
AA1	3	IO_L60P_3	ddr1_dq41		11691.6
V11	3	IO_L59N_3	ddr1_dq42		1638.53
W11	3	IO_L59P_3	ddr1_dq43		1610.19
W5	3	IO_L58N_3	ddr1_dq44		6678.99
W6	3	IO_L58P_3	ddr1_dq45		5936.59
Y3	3	IO_L57N_3/VREF_3	Vref = 1.3V		8909.69

**Table B-1: FPGA Pinout (Cont'd)**

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
Y4	3	IO_L57P_3	ddr1_dq46		8145.63
W7	3	IO_L56N_3	ddr1_dq47		5773.96
W8	3	IO_L56P_3	ddr1_dm5		4826.38
Y6	3	IO_L55N_3	ddr1_a3		5961.45
Y7	3	IO_L55P_3	ddr1_a4		5219.05
AA2	3	IO_L54N_3	ddr1_a5	no_pin5	10317.88
AB2	3	IO_L54P_3	ddr1_a6		11488.21
W9	3	IO_L53N_3	GND		3619.48
W10	3	IO_L53P_3	ddr1_dqs6		2590.48
AA3	3	IO_L52N_3	GND		9502.86
AA4	3	IO_L52P_3	GND		8801.88
AB1	3	IO_L51N_3/VREF_3	Vref = 1.3V		12006.27
AC1	3	IO_L51P_3	ddr1_dq48		12342.28
Y9	3	IO_L50N_3	ddr1_dq49		3554
Y10	3	IO_L50P_3	ddr1_dq50		2606.42
AA5	3	IO_L49N_3	ddr1_dq51		7683.23
AA6	3	IO_L49P_3	ddr1_dq52		7555.89
AB3	3	IO_L48N_3	ddr1_dq53		9319.47
AB4	3	IO_L48P_3	ddr1_dq54		8556.07
AA7	3	IO_L47N_3	ddr1_dq55		5836.46
AA8	3	IO_L47P_3	ddr1_dm6		4888.88
AB5	3	IO_L46N_3	ddr1_a7		7371.9
AB6	3	IO_L46P_3	ddr1_a8		6629.5
AC2	3	IO_L45N_3/VREF_3	Vref = 1.3V	no_pin6	10601.93
AD2	3	IO_L45P_3	ddr1_a9		11866.32
AA9	3	IO_L44N_3	PULLDOWN		3704.71
AA10	3	IO_L44P_3	ddr1_dqs7		2717.14
AC3	3	IO_L43N_3	PULLDOWN		9702.33
AC4	3	IO_L43P_3	PULLDOWN		8911.96
AD1	3	IO_L42N_3	ddr1_dq56		12256.07
AE1	3	IO_L42P_3	ddr1_dq57		12534.09
AB7	3	IO_L41N_3	ddr1_dq58		5986.05
AB8	3	IO_L41P_3	ddr1_dq59		5038.48

Table B-1: FPGA Pinout (Cont'd)

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
AC6	3	IO_L40N_3	ddr1_dq60		6521.49
AC7	3	IO_L40P_3	ddr1_dq61		5779.09
AD3	3	IO_L39N_3/VREF_3	Vref = 1.3V		9751.53
AD4	3	IO_L39P_3	ddr1_dq62		9046.71
AB9	3	IO_L38N_3	ddr1_dq63		3854.3
AB10	3	IO_L38P_3	ddr1_dm7		2906.72
AD5	3	IO_L37N_3	ddr1_a10		8126.55
AD6	3	IO_L37P_3	ddr1_a11		8070.54
AE2	3	IO_L36N_3	ddr1_ckn3	no_pin7	11537.91
AF2	3	IO_L36P_3	ddr1_ck3		11948.48
AD7	3	IO_L35N_3	PULLDOWN		6675.24
AD8	3	IO_L35P_3	ddr1_dqs8		5651.11
AE4	3	IO_L34N_3	PULLDOWN		9342.05
AE5	3	IO_L34P_3	PULLDOWN		8811.79
AG1	3	IO_L33N_3/VREF_3	Vref = 1.3V		12986.31
AG2	3	IO_L33P_3	ddr1_dq64		12391.44
AC9	3	IO_L32N_3	ddr1_dq65		4005.01
AC10	3	IO_L32P_3	ddr1_dq66		3336.69
AF3	3	IO_L31N_3	ddr1_dq67		10624.52
AF4	3	IO_L31P_3	ddr1_dq68		10021.36
AL1	3	IO_L06N_3	ddr1_dq69		15821.97
AL2	3	IO_L06P_3	ddr1_dq70		15583.83
AG7	3	IO_L05N_3	ddr1_dq71		9638.17
AH8	3	IO_L05P_3	ddr1_dm8		9015.73
AH5	3	IO_L04N_3	ddr1_a12		9452.34
AH6	3	IO_L04P_3	PULLDOWN		9308.27
AK3	3	IO_L03N_3/VREF_3	Vref = 1.3V	no_pin8	12802.28
AK4	3	IO_L03P_3	PULLDOWN		12761.57
AJ7	3	IO_L02N_3	ddr1_ckn4		12205.75
AJ8	3	IO_L02P_3	ddr1_ck4		10415.12
AJ4	3	IO_L01N_3/VRP_3	Pulldown to GND for DCI		11311.2
AJ5	3	IO_L01P_3/VRN_3	Pullup to 2.6V for DCI		10985.88
AL5	4	IO_L01N_4/DOUT	GND		13235.56

**Table B-1: FPGA Pinout (Cont'd)**

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
AL6	4	IO_L01P_4/INIT_B	INITn		12205.78
AG9	4	IO_L02N_4/D0	FPGA.DO		6285.75
AH9	4	IO_L02P_4/D1	GND		7853.38
AK6	4	IO_L03N_4/D2	GND		11359.7
AK7	4	IO_L03P_4/D3	GND		11413.02
AF10	4	IO	GND		5273.75
AL7	4	IO_L06N_4/VRP_4	M1_even_clk		12583.91
AM7	4	IO_L06P_4/VRN_4	M1_even_ D15		13750.42
AE11	4	IO_L07N_4	M1_even_ D14		3596.07
AF11	4	IO_L07P_4/VREF_4	M1_even_ D13		4532.67
AG10	4	IO_L08N_4	M1_even_ D12		7946.43
AH10	4	IO_L08P_4	M1_even_ D11		8820.26
AK8	4	IO_L09N_4	M1_even_ D10		11291.37
AL8	4	IO_L09P_4/VREF_4	M1_even_ D9		11372.97
AE13	4	IO_L37N_4	M1_even_ D8		2723.68
AF13	4	IO_L37P_4	M1_even_ D7		3918.86
AG13	4	IO_L38N_4	M1_even_ D6		8007.13
AH13	4	IO_L38P_4	M1_even_ D5		8774.61
AJ11	4	IO_L39N_4	M1_even_ D4		8630.23
AK11	4	IO_L39P_4	M1_even_ D3		9736.03
AE14	4	IO_L43N_4	M1_even_ D2		3696.3
AF14	4	IO_L43P_4	M1_even_ D1		5289.64
AJ13	4	IO_L44N_4	M1_even_ D0		9198.92
AK13	4	IO_L44P_4	M1_odd_clk		10605.95
AL11	4	IO_L45N_4	M1_odd_ D15		10900.17
AM11	4	IO_L45P_4/VREF_4	M1_odd_ D14		12224.04
AE15	4	IO_L46N_4	M1_odd_ D13		3132.45
AF15	4	IO_L46P_4	M1_odd_ D12		3969.05
AG14	4	IO_L47N_4	M1_odd_ D11		8129.77
AH14	4	IO_L47P_4	M1_odd_ D10		9100.75
AL13	4	IO_L48N_4	M1_odd_ D9		9870.11
AL12	4	IO_L48P_4	M1_odd_ D8		11409.38
AD16	4	IO_L49N_4	M1_odd_ D7		2710.75



Table B-1: FPGA Pinout (Cont'd)

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
AE16	4	IO_L49P_4	M1_odd_D6		3442.92
AJ14	4	IO	GND		8953.05
AK14	4	IO	GND		9556.17
AM14	4	IO_L54N_4	M1_odd_D5		12003.32
AM13	4	IO_L54P_4	M1_odd_D4		12348.43
AF16	4	IO_L55N_4	M1_odd_D3		3887.4
AG16	4	IO_L55P_4	M1_odd_D2		4909.89
AH15	4	IO_L56N_4	M1_odd_D1		7000
AJ15	4	IO_L56P_4	M1_odd_D0		8217.31
AL14	4	IO_L57N_4	GND		10563
AL15	4	IO_L57P_4/VREF_4	GND		10160.18
AD17	4	IO_L67N_4	GND		2503.07
AE17	4	IO_L67P_4	GND		3464.19
AH16	4	IO_L68N_4	GND		7362.9
AJ16	4	IO_L68P_4	GND		9128.85
AK16	4	IO_L69N_4	GND		9447.56
AL16	4	IO_L69P_4/VREF_4	GND		10269.32
AF17	4	IO_L73N_4	GND		
AG17	4	IO_L73P_4	GND		
AH17	4	IO_L74N_4/GCLK3S	GND		
AJ17	4	IO_L74P_4/GCLK2P	GND		
AK17	4	IO_L75N_4/GCLK1S	GND		
AL17	4	IO_L75P_4/GCLK0P	GND		
AL18	5	IO_L75N_5/GCLK7S	CLK.SMAN		
AK18	5	IO_L75P_5/GCLK6P	CLK.SMAY		
AJ18	5	IO_L74N_5/GCLK5S	GND		
AH18	5	IO_L74P_5/GCLK4P	GND		
AG18	5	IO_L73N_5	GND		
AF18	5	IO_L73P_5	GND		
AL19	5	IO_L69N_5/VREF_5	GND		
AK19	5	IO_L69P_5	GND		
AJ19	5	IO_L68N_5	GND		
AH19	5	IO_L68P_5	GND		

**Table B-1: FPGA Pinout (Cont'd)**

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
AE18	5	IO_L67N_5	GND		
AD18	5	IO_L67P_5	M2_even_clk		
AL20	5	IO_L57N_5/VREF_5	M2_even_D15		
AL21	5	IO_L57P_5	M2_even_D14		
AJ20	5	IO_L56N_5	M2_even_D13		
AH20	5	IO_L56P_5	M2_even_D12		
AG19	5	IO_L55N_5	M2_even_D11		
AF19	5	IO_L55P_5	M2_even_D10		
AM22	5	IO_L54N_5	M2_even_D9		
AM21	5	IO_L54P_5	M2_even_D8		
AK21	5	IO	GND		
AJ21	5	IO	GND		
AE19	5	IO_L49N_5	M2_even_D7		
AD19	5	IO_L49P_5	M2_even_D6		
AL23	5	IO_L48N_5	M2_even_D5		11409.38
AL22	5	IO_L48P_5	M2_even_D4		9870.11
AH21	5	IO_L47N_5	M2_even_D3		9029.19
AG21	5	IO_L47P_5	M2_even_D2		8186.49
AF20	5	IO_L46N_5	M2_even_D1		3969.05
AE20	5	IO_L46P_5	M2_even_D0		3132.45
AM24	5	IO_L45N_5/VREF_5	M2_odd_clk		12224.04
AL24	5	IO_L45P_5	M2_odd_D15		10900.17
AK22	5	IO_L44N_5	M2_odd_D14		10795.23
AJ22	5	IO_L44P_5	M2_odd_D13		9429.62
AF21	5	IO_L43N_5	M2_odd_D12		5289.64
AE21	5	IO_L43P_5	M2_odd_D11		3696.3
AK24	5	IO_L39N_5	M2_odd_D10		9736.03
AJ24	5	IO_L39P_5	M2_odd_D9		8630.23
AH22	5	IO_L38N_5	M2_odd_D8		8786.32
AG22	5	IO_L38P_5	M2_odd_D7		8056.83
AF22	5	IO_L37N_5	M2_odd_D6		3918.86
AE22	5	IO_L37P_5	M2_odd_D5		2723.68
AL27	5	IO_L09N_5/VREF_5	M2_odd_D4		11372.97

Table B-1: FPGA Pinout (Cont'd)

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
AK27	5	IO_L09P_5	M2_odd_D3		11420.7
AH25	5	IO_L08N_5	M2_odd_D2		8344.01
AG25	5	IO_L08P_5	M2_odd_D1		7652.81
AF24	5	IO_L07N_5/VREF_5	M2_odd_D0		4532.67
AE24	5	IO_L07P_5	GND		3596.07
AM28	5	IO_L06N_5/VRP_5	GND		13858.11
AL28	5	IO_L06P_5/VRN_5	GND		12527.75
AF25	5	IO	GND		
AK28	5	IO_L03N_5/D4	GND		
AK29	5	IO_L03P_5/D5	GND		
AH26	5	IO_L02N_5/D6	GND		
AG26	5	IO_L02P_5/D7	GND		
AL29	5	IO_L01N_5/RDWR_B	PUSH1		
AL30	5	IO_L01P_5/CS_B	PUSH2		
AJ30	6	IO_L01P_6/VRN_6	Pullup to 2.6V for DCI		10985.88
AJ31	6	IO_L01N_6/VRP_6	Pulldown to GND for DCI		11321.01
AJ27	6	IO_L02P_6	dimmm_dm0		10529.58
AJ28	6	IO_L02N_6	dimmm_dm1		11720.34
AK31	6	IO_L03P_6	dimmm_dqs0		12761.57
AK32	6	IO_L03N_6/VREF_6	Vref = 1.3V		12802.28
AH29	6	IO_L04P_6	dimmm_dq0		9308.27
AH30	6	IO_L04N_6	dimmm_dq1		9452.34
AH27	6	IO_L05P_6	dimmm_dq2		8891.47
AG28	6	IO_L05N_6	dimmm_dq3		9638.17
AL33	6	IO_L06P_6	dimmm_dq4		15583.83
AL34	6	IO_L06N_6	dimmm_dq5		15821.97
AF31	6	IO_L31P_6	dimmm_dq6		10021.36
AF32	6	IO_L31N_6	dimmm_dq7		10624.52
AC25	6	IO_L32P_6	dimmm_dm2		3336.69
AC26	6	IO_L32N_6	dimmm_dm3		4005.01
AG33	6	IO_L33P_6	dimmm_dm4	no_pin0	12391.44
AG34	6	IO_L33N_6/VREF_6	Vref = 1.3V		12986.31
AE30	6	IO_L34P_6	PULLDOWN		8811.79

**Table B-1: FPGA Pinout (Cont'd)**

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
AE31	6	IO_L34N_6	PULLDOWN		9342.05
AD27	6	IO_L35P_6	dimmm_dqs1		5651.11
AD28	6	IO_L35N_6	PULLDOWN		6675.24
AF33	6	IO_L36P_6	dimmm_dq8		11948.48
AE33	6	IO_L36N_6	dimmm_dq9		11537.91
AD29	6	IO_L37P_6	dimmm_dq10		8070.54
AD30	6	IO_L37N_6	dimmm_dq11		8126.55
AB25	6	IO_L38P_6	dimmm_dq12		2906.72
AB26	6	IO_L38N_6	dimmm_dq13		3854.3
AD31	6	IO_L39P_6	dimmm_dq14		9046.71
AD32	6	IO_L39N_6/VREF_6	Vref = 1.3V		9751.53
AC28	6	IO_L40P_6	dimmm_dq15		5779.09
AC29	6	IO_L40N_6	dimmm_dm5		6521.49
AB27	6	IO_L41P_6	dimmm_dm6		5038.48
AB28	6	IO_L41N_6	dimmm_dm7		5986.05
AE34	6	IO_L42P_6	dimmm_dm8	no_pin1	12534.09
AD34	6	IO_L42N_6	dimmm_sda		12256.07
AC31	6	IO_L43P_6	PULLDOWN		8911.96
AC32	6	IO_L43N_6	GND		9702.33
AA25	6	IO_L44P_6	dimmm_dqs2		2717.14
AA26	6	IO_L44N_6	GND		3704.71
AD33	6	IO_L45P_6	dimmm_dq16		11866.32
AC33	6	IO_L45N_6/VREF_6	Vref = 1.3V		10601.93
AB29	6	IO_L46P_6	dimmm_dq17		6629.5
AB30	6	IO_L46N_6	dimmm_dq18		7371.9
AA27	6	IO_L47P_6	dimmm_dq19		4888.88
AA28	6	IO_L47N_6	dimmm_dq20		5836.46
AB31	6	IO_L48P_6	dimmm_dq21		8556.07
AB32	6	IO_L48N_6	dimmm_dq22		9319.47
AA29	6	IO_L49P_6	dimmm_dq23		7555.89
AA30	6	IO_L49N_6	PULLDOWN		7683.23
Y25	6	IO_L50P_6	dimmm_ck0		2606.42
Y26	6	IO_L50N_6	dimmm_ckn0		3554

Table B-1: FPGA Pinout (Cont'd)

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
AC34	6	IO_L51P_6	PULLDOWN	no_pin2	12342.28
AB34	6	IO_L51N_6/VREF_6	Vref = 1.3V		12006.27
AA31	6	IO_L52P_6	PULLDOWN		8801.88
AA32	6	IO_L52N_6	PULLDOWN		9502.86
W25	6	IO_L53P_6	dimmm_dqs3		2590.48
W26	6	IO_L53N_6	GND		3619.48
AB33	6	IO_L54P_6	dimmm_dq24		11488.21
AA33	6	IO_L54N_6	dimmm_dq25		10317.88
Y28	6	IO_L55P_6	dimmm_dq26		5219.05
Y29	6	IO_L55N_6	dimmm_dq27		5961.45
W27	6	IO_L56P_6	dimmm_dq28		4826.38
W28	6	IO_L56N_6	dimmm_dq29		5773.96
Y31	6	IO_L57P_6	dimmm_dq30		8145.63
Y32	6	IO_L57N_6/VREF_6	Vref = 1.3V		8909.69
W29	6	IO_L58P_6	dimmm_dq31		5936.59
W30	6	IO_L58N_6	GND		6678.99
W24	6	IO_L59P_6	dimmm_ck1		1610.19
V24	6	IO_L59N_6	dimmm_ckn1		1638.53
AA34	6	IO_L60P_6	dimmm_ck2	no_pin3	11691.6
Y34	6	IO_L60N_6	dimmm_ckn2		11148.48
W31	6	IO_L85P_6	dimmm_s0N		8159.47
W32	6	IO_L85N_6	dimmm_s1N		8919.9
V25	6	IO_L86P_6	dimmm_dqs4		2405.17
V26	6	IO_L86N_6	GND		3327.27
Y33	6	IO_L87P_6	dimmm_dq32		10611.96
W33	6	IO_L87N_6/VREF_6	Vref = 1.3V		9812.03
V29	6	IO_L88P_6	dimmm_dq33		5998.02
V30	6	IO_L88N_6	dimmm_dq34		6547.9
V27	6	IO_L89P_6	dimmm_dq35		4483.54
V28	6	IO_L89N_6	dimmm_dq36		5407.06
V31	6	IO_L90P_6	dimmm_dq37		7799.59
V32	6	IO_L90N_6	dimmm_dq38		8537.7
U32	7	IO_L90P_7	dimmm_dq39		8839.91

**Table B-1: FPGA Pinout (Cont'd)**

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
U31	7	IO_L90N_7	PULLDOWN		7626.14
U28	7	IO_L89P_7	dimmm_rasN	no_pin4	5511.92
U27	7	IO_L89N_7	dimmm_casN		4393.22
V33	7	IO_L88P_7	dimmm_weN		10394.2
U33	7	IO_L88N_7/VREF_7	Vref = 1.3V		9665.64
U30	7	IO_L87P_7	dimmm_rst_dqs_div_out		6851.4
U29	7	IO_L87N_7	dimmm_rst_dqs_div_in		5801.93
U26	7	IO_L86P_7	PULLDOWN		3459.01
U25	7	IO_L86N_7	PULLDOWN		2340.31
T32	7	IO_L85P_7	dimmm_dqs5		9056.44
T31	7	IO_L85N_7	PULLDOWN		7724.5
T30	7	IO_L60P_7	dimmm_dq40		7055.3
T29	7	IO_L60N_7	dimmm_dq41		6031.43
T28	7	IO_L59P_7	dimmm_dq42		5872.43
T27	7	IO_L59N_7	dimmm_dq43		4753.73
T33	7	IO_L58P_7	dimmm_dq44		10173.21
R33	7	IO_L58N_7/VREF_7	Vref = 1.3V		9961.47
R32	7	IO_L57P_7	dimmm_dq45		9271.49
R31	7	IO_L57N_7	dimmm_dq46		8013.89
T26	7	IO_L56P_7	dimmm_dq47		3871.63
T25	7	IO_L56N_7	GND		2752.93
R34	7	IO_L55P_7	dimmm_cke0		11455.67
P34	7	IO_L55N_7	dimmm_cke1		11291.77
R29	7	IO_L54P_7	dimmm_ba0	no_pin5	6425.42
R28	7	IO_L54N_7	dimmm_ba1		4872.84
U24	7	IO_L53P_7	GND		1919.47
T24	7	IO_L53N_7	GND		1247.81
P32	7	IO_L52P_7	dimmm_dqs6		9339.48
P31	7	IO_L52N_7/VREF_7	Vref = 1.3V		8102.88
P30	7	IO_L51P_7	dimmm_dq48		7603.44
P29	7	IO_L51N_7	dimmm_dq49		6499.99
R26	7	IO_L50P_7	dimmm_dq50		3672.29
R25	7	IO_L50N_7	dimmm_dq51		2488.12

Table B-1: FPGA Pinout (Cont'd)

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
P33	7	IO_L49P_7	dimmm_dq52		10530.82
N33	7	IO_L49N_7	dimmm_dq53		10426.76
N32	7	IO_L48P_7	dimmm_dq54		9778.21
N31	7	IO_L48N_7	dimmm_dq55		8437.77
P28	7	IO_L47P_7	dimmm_a0	no_pin6	5954.75
P27	7	IO_L47N_7	dimmm_a1		4770.58
N34	7	IO_L46P_7	dimmm_a2		11804.99
M34	7	IO_L46N_7/VREF_7	Vref = 1.3V		11667.8
N30	7	IO_L45P_7	dimmm_a3		7563.61
N29	7	IO_L45N_7	dimmm_a4		6306.01
P26	7	IO_L44P_7	PULLDOWN		3823
P25	7	IO_L44N_7	PULLDOWN		2638.82
M32	7	IO_L43P_7	dimmm_dqs7		9772.91
M31	7	IO_L43N_7	PULLDOWN		8536.05
L32	7	IO_L42P_7	dimmm_dq56		10259.17
L31	7	IO_L42N_7	dimmm_dq57		9001.57
N28	7	IO_L41P_7	dimmm_dq58		6104.35
N27	7	IO_L41N_7	dimmm_dq59		4920.17
M33	7	IO_L40P_7	dimmm_dq60		12186.54
L33	7	IO_L40N_7/VREF_7	Vref = 1.3V		11195.56
M29	7	IO_L39P_7	dimmm_dq61		6975.04
M28	7	IO_L39N_7	dimmm_dq62		5610.09
N26	7	IO_L38P_7	dimmm_dq63		3972.59
N25	7	IO_L38N_7	PULLDOWN		2788.42
L34	7	IO_L37P_7	dimmm_a6		12451.17
K34	7	IO_L37N_7	dimmm_a7		12423.45
L30	7	IO_L36P_7	dimmm_a8	no_pin7	8143.52
L29	7	IO_L36N_7	dimmm_a9		7340.48
L28	7	IO_L35P_7	dimmm_a5		6793.53
L27	7	IO_L35N_7	GND		5592.79
K33	7	IO_L34P_7	dimmm_dqs8		11352.59
J33	7	IO_L34N_7/VREF_7	Vref = 1.3V		12123.95
K31	7	IO_L33P_7	dimmm_dq64		9537.04

**Table B-1: FPGA Pinout (Cont'd)**

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
K30	7	IO_L33N_7	dimmm_dq65		8267.43
M26	7	IO_L32P_7	dimmm_dq66		4123.3
M25	7	IO_L32N_7	dimmm_dq67		3062.48
H34	7	IO_L31P_7	dimmm_dq68		13451.41
H33	7	IO_L31N_7	dimmm_dq69		12137.04
F31	7	IO_L06P_7	dimmm_dq70		11858.77
F30	7	IO_L06N_7	dimmm_dq71		10666.81
J28	7	IO_L05P_7	dimmm_a10	no_pin8	7292.33
J27	7	IO_L05N_7	dimmm_a11		6469.14
E34	7	IO_L04P_7	dimmm_a12		15132.61
E33	7	IO_L04N_7/VREF_7	Vref = 1.3V		13663.12
E32	7	IO_L03P_7	dimmm_sa0		13396.34
E31	7	IO_L03N_7	dimmm_sa1		11802.85
F28	7	IO_L02P_7	dimmm_sa2		11146.23
F27	7	IO_L02N_7	dimmm_scl		12438.46
D34	7	IO_L01P_7/VRN_7	Pullup to 2.6V for DCI		15547.77
D33	7	IO_L01N_7/VRP_7	Pulldown to GND for DCI		14050.12
J26		PROG_B	PROGRAMn		
K25		HSWAP_EN	HSWAP		
K26		DXP			
G27		DXN			
A29		TXNPAD4			
A28		TXPPAD4			
A27		RXPPAD4			
A26		RXNPAD4			
A21		TXNPAD6			
A20		TXPPAD6			
A19		RXPPAD6			
A18		RXNPAD6			
A17		TXNPAD7			
A16		TXPPAD7			
A15		RXPPAD7			
A14		RXNPAD7			



Table B-1: FPGA Pinout (Cont'd)

Pin Numbers	Virtex-II Pro Bank Number	Package Functional Name	I/O Pin Names	Internal Script Information	Package Flight Times (in microns)
A9		TXNPAD9			
A8		TXPPAD9			
A7		RXPPAD9			
A6		RXNPAD9			
G8		RSVD			
K9		VBATT			
K10		TMS	TMS		
J9		TCK	TCK		
H7		DO	TDO.FPGA.to.TDO.PORT		
AE9		CCLK	FPGA.CCLK		
AF9		PWRDWN_B	PWRDWN		
AE10		DONE	DONE		
AP6		RXNPAD16	RXNPAD18		
AP7		RXPPAD16	RXPPAD18		
AP8		TXPPAD16	TXPPAD18		
AP9		TXNPAD16	TXNPAD18		
AP14		RXNPAD18	RXNPAD18		
AP15		RXPPAD18	RXPPAD18		
AP16		TXPPAD18	TXPPAD18		
AP17		TXNPAD18	TXNPAD18		
AP18		RXNPAD19			
AP19		RXPPAD19			
AP20		TXPPAD19			
AP21		TXNPAD19			
AP26		RXNPAD21			
AP27		RXPPAD21			
AP28		TXPPAD21			
AP29		TXNPAD21			
AE25		M2	M2		
AF26		M0	M0		
AE26		M1	M1		
H28		TDI	TDO.PROM.to.TDI.FPGA		

